PHOTOGRAPHIC

SCIENCE

and TECHNIQUE
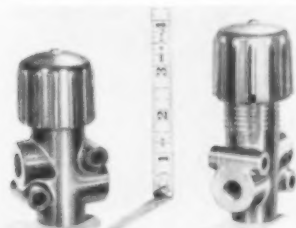
FEBRUARY 1957

Series II, Volume 4, Number 1

IN THIS ISSUE

PLASTIC VALVES FOR PROCESSING

A new series of general purpose rigid P.V.C. (Polyvinyl Chloride) valves designed to withstand high temperatures and pressures too severe for ordinary plastic materials are offered by Chemtrol Corp., 11008 Santa Fe Avenue, Lynnwood, California. The Chemtrol valves operate up to 170 psi, continuous duty, and in lower pressure systems may be used safely at temperatures up to 170 F., or higher for intermittent duty. They have excellent corrosion resistance, outstanding and constant flow characteristics, and immunity to electrolysis and galvanic action.

Non-toxic and non-contaminating to fluids or gasses, the valves will resist most of the chemicals that stainless steel will, and others in addition. The valves, needle and globe types, are available in $1/8''$ and $1/4''$ pipe sizes and $1/8''$, $1/4''$ and $3/8''$ O.D. male tube connections, and may be used to great advantage with alloy metal tubing where temperatures and pressures allow.

Positive shut-off is assured by use of a "Kel-F" needle and a new offset design that creates 50% less pressure drop as the fluid undergoes less change of direction. A new-type "Quad Ring" seal affords low and high pressure as well as high vacuum seal in both directions.

On the Globe Valve, the seating disc is non-sticking Teflon. Only finger-tip pressure is required to open the valve. Like the Needle Valve, the Globe Valve has O-ring type spindle seals and the working parts are sealed against interior and exterior corrosion. The Globe Valve's non-rising stem is actuated by a double lead thread from full open to close in three turns, yet allows throttling.

To the Editor:

I am informed that a letter, which contains the following statements, has been circulated to members of the Photographic Society of America, and to other persons active in the photographic community:

(a) that there has been a merger of the PSA Technical Division with another group to form a new society.

(b) that, as a result of this "consolidation," publication of PHOTOGRAPHIC SCIENCE AND TECHNIQUE will be suspended.

BOTH OF THESE STATEMENTS ARE UNTRUE—since there has been no such merger.

Because it is difficult to determine how much currency has been given to the letter mentioned above, I believe that the greatest number of interested people will be informed of these misstatements by giving this memorandum the most possible prominence in the regular February issue of PS&T.

M. M. Phegley, President

PROFESSIONAL PRINT WASHER

Now available is a print washer for only $64.50 which will accept 16 × 20 prints. Called the Richard Professional model, it washes 125 or more 8 × 10 prints per batch in less than 20 minutes. The 30 inch diameter washer body is made of smooth white plastic which is durable and acid-resistant. The manufacturer, RICHARD MANUFACTURING CO., 5914 Noble Ave., Van Nuys, Calif., will gladly send technical data upon request.

BOARD OF ASSOCIATE EDITORS

Paul Arnold, APSA, Hon. PSA, EDITOR
26 Hotchkiss Street, South
Binghamton, New York

Morris Gurrie, APSA	5412 N. Bernard Street	Chicago 25, Illinois
R. C. Hakanson, APSA	10322 Lake Shore Boulevard	Cleveland 8, Ohio
T. Howard James, APSA	Kodak Research Laboratories	Rochester 4, New York
A. E. Neumer, APSA	635 St. Paul Street	Rochester 2, New York
John B. Taylor	118 Laurel Avenue	Binghamton, New York

INTERVAL COUNTING TIMER FOR PRECISE PHOTOGRAPHIC PROCESSING

Louis E. Owen*

ABSTRACT

A timer suitable for precise photographic processing is described. Operation is based upon the counting of pulses produced at fixed intervals by a switch which is actuated from a cam driven by a synchronous motor. Read-outs at selected number of counts provide aural warning of the impending end of the development period, visual indication of the end of the development and short-stop periods, and indication of the end of the fixing period by de-energizing the agitator motor of the developing machine and sounding a buzzer. Switch selection of various developing periods and fixing periods is provided.

SPECTROCHEMICAL LABORATORIES employing photographic emulsions require reproducible photographic processing conditions. One of the required conditions involves the precise control of the developing time. Timers of the pacer type have proven to be useful in eliminating the differences in judgment and handling between individual laboratory workers. Cam-driven timers are most generally useful (1) but, when a long period total cycle is required, it is difficult to set the operating point of the cams with the desired accuracy for the developing period. Furthermore, the cams are not easy to reset for use with different emulsion types requiring different processing periods. In the spectrographic laboratory of the Goodyear Atomic Corporation, a new timer (Fig. 1) has been developed, which is a member of a general line of controllers based upon the counting of timed intervals.

The controller generates repetitive electrical pulses at intervals spaced by a synchronously motor-driven cam operating a snap-action switch. These pulses are counted by stepping switches.

In the first design, the timed intervals were counted on two decade counters capable of controlling to ninety-nine counts. The subsequent switching problems have been simplified in the timer described here by the use of longer intervals counted on a single, forty-contact stepping switch. Twenty-second intervals provide a total time cycle of 13 minutes and 20 seconds.

Read-out relays are arranged to operate at predetermined number of counts appearing on the stepping switch. These read-out relays can provide aural and visual indication to the operator or can directly control time related processes. The operating points of the read-out relays are controlled by a selector switch of several decks. As the set point of the critical period (i.e., developing period) is changed, all set points of related functions are automatically readjusted to have the proper relation to the critical period.

In a more generalized two decade timer-controller than described here, each read-out relay may be connected to two, ten-position switches wired to the counting switches. Each pair of ten-position switches may be set to determine the count point at which its associated relay operates.

Operation of the Counter

As the operator places the photographic material in the developer tray of the developing machine, he presses a push button switch S_3 on the timer (Fig. 1). This starts the timer on its cycle and energizes the rocking or agitating motor of the machine. A pilot light Pl_1 on the timer case is extinguished simultaneously.

Twenty seconds before the end of the development period, a buzzer in the timer case sounds for 5 seconds. This warns the operator, who has been free to leave the darkroom, that the developing time is nearly complete. At the end of the development period, a pilot light Pl_2 is illuminated. The operator immediately removes the film or plate from the developer and places it in the short-
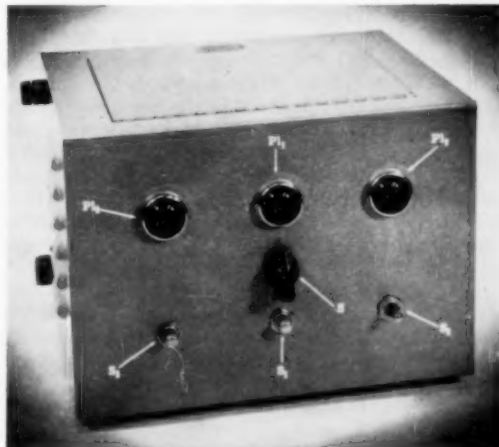
Fig. 1. Cabinet and control panel of the interval timer. The timing cycle is started by closing switch S_2. The pilot light Pl_1 is on when the unit is ready but not running.

stop, hardening bath. Upon completion of the period for the second bath, another pilot light Pl_3 is illuminated. The operator then moves the film to the tray or tank containing the fixing-clearing bath. He is again free to leave the darkroom.

At the end of the clearing period, the agitating motor of the developing machine is turned off. The photographic material is then ready to be washed. Simul-

taneously, the buzzer again sounds until the operator returns to the darkroom and turns it off by means of the push button switch S_1.

In the model shown, switch S_2 permits selection of one of three clearing times according to the emulsion being processed.

Having completed its cycle of timing control, the timer is automatically reset and the center pilot light Pl_1 comes on to show that the timer is again ready for use.

The three pilot lights are of different intensities. The pilot light Pl_1 is very dim so as not to affect the emulsion. Pilot light Pl_2 is also very subdued, but of a hue differing from Pl_1. Pilot light Pl_3 is brighter as the emulsion is exposed to it only after having been through the stop bath.

This timer provides precisely determined periods and by virtue of its pacing type of indication tends to eliminate differences attributable to individual workers.

Circuit Operation

The wiring diagram (Fig. 2) shows the circuit of a timer designed to provide a choice from six developing periods and three fixing periods. As drawn, the timer is set for a 4-minute development and 5-minute fixation period, but it is not energized or running. The contact points of the six decks S_A, S_B, S_C, S_D, S_E, and S_F of the selector switch S are connected to the contact points of the stepping relay SR at the contact numbers indicated. For clarity, the actual interconnections are not shown.

When the instrument is connected to the line, relay R_1 is energized transferring the normal position of its contact R_{1A} to relay R_2 and pilot light Pl_1 is closed. Pl_1 is illuminated to show that the unit is ready for use.

The unit starts its timing cycle when push button switch S_3 is operated. This completes the circuit to relay R_1 which holds in through the normally open side of R_{1B}. The normally closed side of R_{1B} opens and extinguishes the "ready" pilot light Pl_1. Simultaneously, the agitator motor M_2 is energized. Contact R_{1A} closes to start the cam driving motor M_1.

Delay relay R_2 closes its contact R_{6A} after 5 seconds. At the moment of start-up, switch S_4 is closed and would pulse the stepping coil R_8 for a false count if not held off by contact R_{6A}.

As M_1 revolves, it closes switch S_4 once every 20 seconds. Each time S_4 closes, it energizes the stepping coil R_8 of relay R. The stepping contact of R therefore advances one contact step every 20 seconds.

After the first 20 seconds, the stepping switch is pulsed by S_4 and advances from contact 0 to contact No. 1. Relay R_1 is de-energized and its contact R_{1A} returns to its normal position. The normally open side of R_{1A} removes R_6 from the circuit while the normally closed side helps complete the circuit to coil R_8 through the normally closed side of R_{3C}.

In the instrument as drawn, when R comes to the eleventh step (3 min. 40 sec.), a circuit is completed through deck S_A of the time setting switch S to delay relay R_2 and the buzzer B. The buzzer, therefore, sounds. In approximately 5 seconds, R_2 opens its contact R_{2A}, silencing the buzzer. The buzzer has operated to warn the worker of the impending end of the development period.
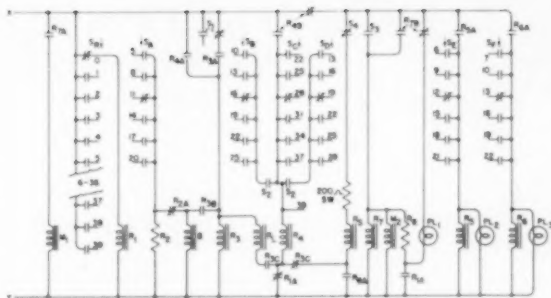
At the count of twelve (4 min.), a circuit is completed through deck S_E of S to relay R_5, which locks to the line by means of its contact R_{5A}. Pilot light Pl_2 is illuminated at the same time to signal the end of the developing period. The worker then transfers the photographic material to the short-stop, hardening bath.

When thirteen intervals (4 min. 20 sec.) have been counted, deck S_F similarly operates relay R_6 and pilot light Pl_3 to indicate the end of the short-stop bath period.

Deck S_C, as drawn, controls the fixation period. At the count of twenty-eight, relay R_4 is energized. The normally open side of R_{4B} closes to lock R_4 to the line X. The normally closed side of contact R_{4B} opens to drop out relays R_5, R_6, and R_7. Pilot lights Pl_2 and Pl_3, therefore, go out and the motors M_1 and M_2 stop.

The normally open side of R_{4A} closes to bring in relay R_3, which locks to line X through its contact R_{3A}. The normally open side of R_{3C} closes to energize the stepping switch release coil R_B which permits the spring driven return of the stepping contact to the zero count position. In the zero count position, the circuit to relay R_1 is completed. The normally closed R_{1A} opens and deactivates R_4.

The buzzer is sounded at the end of the complete cycle by the circuit through R_{7B}. It may be silenced by the momentary operation of switch S_1, which de-energizes R_6. The normally open side of S_1 can be used to furnish a starting pulse to a solenoid operated photographic washer.

The pilot light Pl_1 was illuminated when R_{7B} returned to its normally closed position and the normally open side of R_{1A} closed when R_1 operated as the stepping switch contact returned to the zero count position. It indicates that the timer is ready for repeat operation.

If the time selector switch had been set for a different developing period as selected by deck S_E, the proper operating points for the other functions would have been automatically set. Deck S_A always provides a warning buzzer 20 seconds (one count) before the end of the developing period. Similarly, deck S_F calls for the end of the short-stop period 20 seconds (one count) after the end of the developing period.

The center-position-off switch S_2 selects deck S_B, S_C, or S_D as the controller of the fixation period. Deck S_B is three counts, S_D is six counts, and S_C is fifteen counts later than the short-stop signal to provide 1-, 2-, or 5-minute fixation periods, respectively.

FIG. 2. PACING-TYPE PHOTOGRAPHIC PROCESSING TIMER
(SET FOR 4 MIN DEVELOPMENT - 5 MIN FIX BUT NOT ENERGIZED)

The circuit described is mounted in a metal cabinet (7 by 8 by 10 inches). It is electrically connected to a commercial developing machine. Developing machines with sufficient unused space would permit internal mounting.

Discussion

The precision with which the actual photographic processing periods are controlled is influenced by the bath transfer techniques of individual workers. However, a pacing type of indication seems to promote the greatest uniformity which can be achieved with manual manipulation.

This timer-controller has proven to be a valuable laboratory tool providing a versatile service hitherto unobtainable. In the Goodyear Atomic laboratory, it has enhanced the usefulness of a commercial developing machine to which it has been connected. The principles involved are being applied to the control of a completely automatic developing machine.

Reference

1. Owen, L. E., "Rev. Sci. Instr., Vol. 17, pp. 155, 156 (1946).

AMERICAN STANDARDS FOR PHOTOGRAPHIC PROCESSING

J. I. Crabtree*

As THE APPOINTED representative of the Photographic Society of America, the Chairman of the Sectional Committee PH4 of the American Standards Association, dealing with standards on photographic processing, has served since the Committee was organized in 1950. It may be of interest to the members of the Society to learn of the accomplishments of the American Standards Association in this field of endeavor to which a number of PSA members have given time and attention.

"The American Standards Association is a privately financed federation of national trade associations, professional societies, and consumer organizations with a company membership representing a cross section of commerce and industry.

"An American Standard is therefore a voluntary agreement reached by the consensus of those skilled in the art. It is an agreement on a standard for a material or product, a process or procedure, an operation, or usage.

"Standardization is dynamic and not static and consists in finding out the best way of doing a thing and then doing it that way until a better way is discovered. In its broadest sense, therefore, standardization applies not only to such matters as weights and measures and material objects but it permeates most fields of human endeavour."[1]

Method of Approving American Standards

In approving American Standards, "the basic principle is that a consensus of those having a substantial interest in the scope and provisions of a proposed standard must be reached. Any group having such a substantial interest has the inherent right of representation

on the committee dealing with the subject matter of the standard which is known as the "Sectional Committee."

Before seeking approval by the American Standards Association, the committee must bring the subject to the attention of others known to have a substantial interest in the matter for comment and all objections must be dealt with before approval as an American Standard can be given. The Association provides the machinery through which the groups themselves arrive at decisions. It takes up a new project only upon request of a responsible organization or group. The project may deal with an existing standard already in general use, or one which it is proposed shall be generally accepted; or it may involve the development of an entirely new standard. It may be any one of a wide variety of types, such as: dimensional standards; specifications for materials; methods of test; performance specifications; methods of analysis; definitions of technical terms, etc.

The subject matter for standardization may be proposed either by a member of one of the ASA Committees or by any outside person or group in which latter case the proposal is received by the headquarters of the American Standards Association and routed to the appropriate committee chairman. The Standards Council or its delegated agency, however, must approve the initiation of a new project and approve the carefully worded "Scope" of the proposed standard.[2,3]

It is then customary to assign the proposal to one or more members of a subcommittee to prepare a preliminary draft which is then fully discussed by the full committee and submitted for criticism to the various interested manufacturers, consumers, and experts throughout the country. The received suggestions and criticisms are then carefully considered and incorporated in the final draft which is then circulated to the Sectional Committee for trial and criticism.
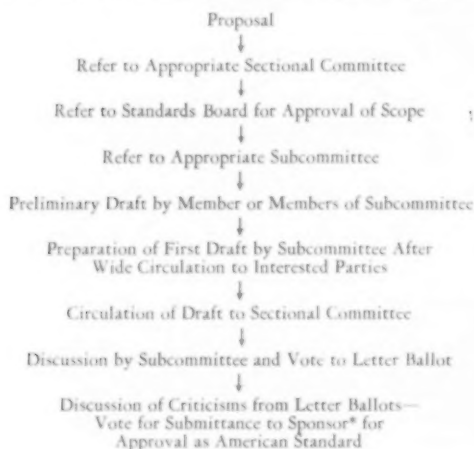
At an ensuing meeting of the Sectional Committee, the standard is then studied in detail and it is voted

* Eastman Kodak Company, Rochester 4, New York. Chairman of ASA Sectional Committee PH4 (Photographic Processing) and Chairman (1943-1950) of Subcommittee 8 (Processing) of ASA Sectional Committee Z38 on Photography. Received 28 December 1956.

either to (a) submit the proposed standard to Letter Ballot of the entire Sectional Committee, or (b) to return it to the subcommittee for reconsideration. At a subsequent meeting of the Sectional Committee, suggestions and criticisms are considered further and a vote taken either to (a) approve the standard for submittance to the sponsor (Photographic Standards Board) or (b) again refer it back to the subcommittee. With a favorable vote of the Standards Board, the standard is then referred to the Standards Council, through The Board of Review, for approval as an American Standard.

From the above, it is seen that a tremendous amount of effort is made to insure that there is essentially universal agreement among those "skilled in the art" before a proposal becomes an American Standard. Most of the chemical standards enumerated below were referred for comment to at least 35 organizations not represented directly on the Sectional Committee before they received final approval.

The following scheme summarizes the above procedure:

Proposal
↓
Refer to Appropriate Sectional Committee
↓
Refer to Standards Board for Approval of Scope
↓
Refer to Appropriate Subcommittee
↓
Preliminary Draft by Member or Members of Subcommittee
↓
Preparation of First Draft by Subcommittee After
Wide Circulation to Interested Parties
↓
Circulation of Draft to Sectional Committee
↓
Discussion by Subcommittee and Vote to Letter Ballot
↓
Discussion of Criticisms from Letter Ballots—
Vote for Submittance to Sponsor* for
Approval as American Standard

Standards for Photographic Processing

Previous to 1939 there was no universal agreement amongst photographers regarding matters such as methods of determining film speeds or manipulative procedures during processing so as to produce a constant result in a fixed time and to encourage the use of more uniform practices in the processing of exposed sensitive materials. However, under the sponsorship of the Optical Society of America, a Sectional Committee on Photography of the American Standards Association, termed Z38, was formed under the chairmanship of Loyd A. Jones who established several subcommittees including one on Photographic Processing under the chairmanship of the present author. The committee was fully representative of manufacturers, distributors, consumers, and technical specialists including technical representatives from concerns such as duPont, Ansco, Kodak, Remington Rand, the National Bureau of Standards, Master Photo Finishers of America, and the Armed Services.

* The sponsor is the Standards Board which directs the work of the Sectional Committee.

This committee was further divided into the following subcommittees: (a) Processing Equipment under the chairmanship of V. J. Moyes and, later, J. C. Reddig, (b) Processing Chemicals under the chairmanship of S. E. Sheppard and, later, C. V. Otis, and (c) Processing Procedures, under the chairmanship of H. A. Mac-Donough.

In November 1950 Committee Z38 was abolished and a new series of Sectional Committees established dealing with photography, namely PH1 (The Physical and Chemical Characteristics and Packaging of Photographic Films, Plates, and Papers), PH2 (Sensitometry), PH3 (Apparatus), PH4 (Processing), and PH5 (Reproduction of Documents). The present author, representing the Photographic Society of America, was elected chairman of PH4 and appointed subcommittees as follows: PH4-1, *Photographic Chemicals*, under the chairmanship of C. V. Otis and, later, G. C. Alletag; PH4-2, *Processing Procedures*, under the chairmanship of H. A. Mac-Donough and, later, R. N. Linkhart; PH4-3, *Processing Equipment* under the chairmanship of J. C. Reddig and, later, Leo Pavelle. Mr. Otis served as a very effective secretary of PH4 until 1955 being succeeded by Mr. G. C. Alletag and, later, by Miss Mary J. Finnegan.

The reader is naturally interested mostly in the accomplishments of the above committees which were not insignificant amounting to 86 Approved Standards to date, apart from the work involved in revising standards at periodic intervals.

Chemical Standards

"Photographic processing inherently involves chemical operations which require adequate purity of the chemicals to attain a high standard of photographic quality."[4] As a result, it has been found desirable to set up standards of purity for "photographic grade" chemicals to meet the requirements of the various sensitive materials and processes. These chemicals fall into groups according to their use or chemical nature: developing agents, alkalies, sulfites, restrainers and antifoggants, fixing agents, acids, hardeners, and a group of miscellaneous chemicals.

The term *photographic grade* refers to chemicals in which impurities known to be photographically harmful are limited to a safe quantity, while inert impurities are restricted to amounts that will not reduce the required assay strength. In general, the chemical tests and analyses of the specifications are intended to indicate the presence of photographically detrimental impurities which might occur in the production and supply of the chemicals.

Instances of harmful types of substances which are limited in appropriate chemicals by these specifications are the following: (1) chemical reducing and sulfiding agents which can initiate fog or stain when present in developers, (2) chemical reducing and sulfiding agents which can produce fog or stain when present in fixing baths, (3) powerful restraining agents, (4) excessive silver halide solvents in developers, (5) catalysts capable of accelerating the deterioration of photographic solutions, and (6) precipitate-forming compounds and insoluble matter.

While it is considered that the chemical methods of testing are adequate in most cases, it is recognized that

the ultimate criterion of satisfactory quality is the successful performance of a given chemical in a use test, that is, in the recommended formula with a given sensitive material and under the prescribed conditions of use.

Value of the Standards

It is believed that general adoption of these American Standard specifications for photographic grade chemicals will prove helpful by (1) establishing a distinctive grade of chemicals for use in processng photographic materials, (2) providing manufacturers, suppliers, and consumers with uniform standards of quality, (3) providing more satisfactory reference standards to cover the ingredients used in supplying packaged formulas covered by government specifications (some reference has been made inappropriately to CP and USP grades in the past), and (4) giving manufacturers of sensitized materials assurance that their materials will be processed in formulas compounded from chemicals of satisfactory quality. It is recognized, of course, that the formulas and techniques employed are of at least equal importance in processing. It should be borne in mind, however, that the use of standard chemicals cannot be forced on anybody. Public opinion alone can be the criterion, but low-grade low-price materials will always be foisted on the public.

The following specifications have of necessity been based largely on data available on the requirements of the processes normally employed in black-and-white photography, since at the time the project was undertaken the requirements of the color processes were not too clearly defined. Consideration has been given to the requirements for motion picture processing including reversal processing. Indications at the present time are that the present specifications are entirely adequate insofar as use of the chemicals in existing color processes is concerned.

The following chemical standards have been approved to date:

Acetic Acid, Glacial (Z38.8.100–1949).
Sulfuric Acid (Z38.8.101–1949).
Citric Acid (Z38.8.102-1949).
Boric Acid, Crystalline (Z38.8.103–1949).
Hydrochloric Acid (Z38.8.104–1949).
Sodium Acid Sulfate, Fused (PH4.105–1952).
Acetic Acid, 28% (Z38.8.106–1949).
Citric Acid, Anhydrous (PH4.107–1954).
Mono-Methyl-Para-Aminophenol Sulfate (Z38.8.-125–1948).
Hydroquinone (PH4.126–1955).
2,4-Diaminophenol Hydrochloride (Z38.8.127–1948).
Para-Hydroxyphenylglycine (Z38.8.128–1949).
Para-Aminophenol Hydrochloride (Z38.8.129–1948).
Pyrogallic Acid (Z38.8.130–1948).
Catechol (Z38.131–1948).
Para-Phenylenediamine (Z38.8.132–1948).
Para-Phenylenediamine Dihydrochloride (Z38.8.-133–1948).
Chlorohydroquinone (Z38.8.134–1948).
Mono-Benzyl-Para-Aminophenol Hydrochloride (PH4.135–1954).

Aluminum Potassium Sulfate (Z38.8.150–1949).
Chromium Potassium Sulfate (Z38.8.151–1949).
Formaldehyde Solution (Z38.8.152–1949).
Paraformaldehyde (Z38.8.153–1949).
Sodium Sulfate, Anhydrous (Z38.8.175–1949).
Sodium Acetate, Anhydrous (Z38.8.176–1949).
Isopropylamine, 50% Aqueous Solution (PH4.178–1954).
Sodium Citrate (PH4.179–1956).
Copper Sulfate (Z38.8.180–1949).
Benzyl Alcohol (PH4.181–1954).
Sodium Sulfide, Fused (Z38.8.182–1949).
Ammonium Chloride (PH4.183–1953).
Ammonium Sulfate (PH4.184–1953).
Potassium Bromide (PH4.200–1955).
Potassium Iodide (Z38.8.201–1948).
Potassium Chloride (Z38.8.202–1948).
Sodium Chloride (Z38.8.203–1948).
Benzotriazole (PH4.204–1955).
5-Methylbenzotriazole (Z38.8.205–1948).
6-Nitrobenzimidazole Nitrate (Z38.8.206–1948).
Sodium Bromide (PH4.207–1954).
Sodium Hydroxide (Z38.8.225–1948).
Potassium Hydroxide (Z38.8.226–1948).
Sodium Carbonate, Monohydrate (PH4.227–1954).
Sodium Carbonate, Anhydrous (PH4.228–1954).
Potassium Carbonate (Z38.8.229–1948).
Sodium Tetraborate, Decahydrate (PH4.230–1954).
Sodium Metaborate, Octahydrate (PH4.231–1954).
Ammonium Hydroxide (Z38.8.232–1948).
Sodium Tetraborate, Pentahydrate (PH4.233–1954).
Sodium Thiosulfate, Anhydrous (PH4.250–1953).
Sodium Thiosulfate, Crystalline (PH4.251–1953).
Ammonium Thiosulfate, 60% Solution (PH4.252–1953).
Ammonium Thiosulfate (PH4.253–1953).
Sodium Sulfite (PH4.275–1952).
Sodium Bisulfite (Z38.8.276–1949).
Potassium Metabisulfite (Z38.8.277–1948).
Potassium Dichromate (Z38.8.177–1949).
Potassium Permanganate (Z38.8.178–1949).
Potassium Ferricyanide (Z38.8.179–1949).
Potassium Persulfate (Z38.8.181–1949).

Photographic Processing Procedure Standards

Previous to the time of Hurter and Driffield, photographic processing was a more or less "hit and miss" operation with little or no thought given to control of such factors as time, temperature, and degree of agitation of the processing solutions.

Hurter and Driffiel[4] devised methods of measuring the characteristics of sensitive photographic materials but, strange to say, previous to the inauguration of the ASA Committee, surprisingly little attention was given to the factor of manipulation in processing. For example, gamma was usually stipulated in terms of time and temperature with little or no consideration to the precise degree of agitation as determined by manipulation which is usually as important a factor as time or temperature.

In the past, some manufacturers and authors have stipulated a processing temperature of 65 F and others 70 F. Apparatus was frequently constructed with no thought of the corrosion properties of the material in corrosive solutions such as acid fixing baths. Processing

tanks were of indefinite size and the capacity was frequently measured when full to the brim instead of at the working level. Many film hangers were not interchangeable and film clips often encroached on the picture area.

The means of correcting these and other deficiencies has been provided by the work of the ASA Committees. Perhaps with more publicity, the accomplishments would be more universally appreciated both by manufacturers and users.

The following standards have been adopted to date:

Temperature for Photographic Processing Solutions (PH4.5-1953). While photographic processing may be carried out over a wide range of temperatures and certain specialized procedures may require specific temperatures, it has generally been accepted that 68 F represents the most commonly employed single processing temperature.

Method for Converting Weights and Measures for Photographic Use (PH4.6-1953). This is of value both to manufacturers and users and has been approved by the National Bureau of Standards.

Photographic Processing Manipulation of Films and Plates (Z38.8.3-1947); *Photographic Processing Manipulation of Paper* (Z38.8.6-1949). It is of little use to stipulate that a film or plate will develop to a gamma of say 0.74 in a given developer in x minutes at 68 F unless the conditions of agitation are stated as determined by the precise method of manipulation. The American Standard agitation procedure has been incorporated in both textbooks and instruction sheets of manufacturers.

Procedure for Determining the Safety-Time of Photographic Darkroom Illumination (Z38.8.13-1950). This is of value to the user for insuring that he does not accidentally fog his sensitive films or plates and is of value to the manufacturer by insuring more satisfactory use of his materials.

Method for Indicating the Stability of the Images of Processed Black-and-White Films, Plates, and Papers (PH4.12-1954). This enables the user to insure that the photographs which he has made will not undergo serious deterioration with age.

Method for Determining the Melting Point of a Non-Support Layer of Films, Plates, and Paper in Distilled Water (Z38.8.20-1948). The melting point (in water) of the gelatin layer of a processed film, plate or paper gives some indication of the degree of hardening the material has received during processing, usually in the fixing bath, and such a determination is useful in evaluating the relative hardening properties of fixing and hardening solutions.

Method for Determining Maximum Safe Temperatures for Photographic Processing Solutions (Z38.8.19-1948). This is valuable to manufacturers and users for determining the relative degree of hardening of film or plate emulsions before or after any given processing treatment.

Method for Determining the Thiosulfate Content of Processed Photographic Film (PH4.8-1953). In order to insure that the photographic image will not deteriorate with age, one criterion is that it be free from hypo. This standard gives full practical details for carrying out the test which is based on the formation of a white precipitate of silver mercurous chloride by interaction of hypo and mercuric chloride. An outline of the procedure is also given in the American Standard Specifications for Films for Permanent Records, Z38.3.2.

Method for Determining Residual Thiosulfate and Tetrathionate in Processed Photographic Papers (Z38.8.25-1950). The presence of residual hypo in papers is even more harmful than in the case of films. The method is based on the reaction between hypo and silver nitrate to give a brown deposit of silver sulfide.

Definition of a Fine Grain Developer (PH4.14-1956). A fine grain developer is defined as one that will produce negatives which, when printed at an enlargement of 20 diameters, show a graininess pattern no more apparent than that produced by the use of a borax accelerated reference developer. In general, the test method is as follows: Strips are cut from the chosen film and exposed in a sensitometer. Exposed strips are then processed in each of the developer solutions (the test developer and the reference developer). The sensitometric characteristics are evaluated for each developer. Additional strips of film are then evenly flashed to prescribed densities and processed. From these strips, enlargements are made on glossy paper. The paper prints are then processed and the graininess pattern produced by the two developers compared.

Requirements for Photographic Wetting Agents (Z38.8.14-1950). This standard is designed to insure that the processing solution will tend to act in a uniform manner over the entire surface of the photographic film, plate, or paper and that, after washing and treatment in an aqueous solution of the wetting agent, the water solution will drain away uniformly, thus facilitating uniform drying.

Standards for Photographic Apparatus

Specifications for Photographic Trays (PH4.3-1952). This was designed to insure that the trays will adequately accommodate the various standard sizes of films, plates, and papers, and deals with matters such as depth of tray, height of ribs, shape of pouring lip, and corrosion resistance of the construction material.

Specifications for Sheet Film Processing Tanks (PH4.2-1952). The standard defines minimum inside dimensions of (a) straight-walled tanks when the hangers rest on the top edges, and (b) tanks with flanged rims extending above the hanger ledge so that a cover may be used with the hanger in position.

Specifications for Channel-Type Photographic Hangers (PH4.4-1952). *Internal Dimensions for Radiographic Film Processing Tanks* (Z38.8.7-1946). *X-Ray Sheet Film Hangers (Clip-Type)* (PH4.18-1954). *Internal Dimensions for Deep Tanks for Manual Processing of Amateur Roll Film* (PH4.19-1956). *Channel-Type Multiple Photographic Hangers* (PH4.22-1956). These are of particular value to the user by insuring greater interchangeability of tanks from various manufacturers, that the tanks will hold the volume of liquid corresponding to the rated capacity when at working level, and that the hangers are tailored to the tanks and are interchangeable.

Dimensions for Bite of Film Clips (PH4.15-1954). This was designed to insure that the photographic image is not impaired by encroachment of the jaw of the film clip.

Photographic Thermometers (Z38.8.11-1948). To date thermometer makers have given little or no thought to the requirements of thermometers for photographic use with the result that invariably the paint in the gradua-

tion marks is rapidly removed by alkaline developers. In particular, this specification has been a means of stimulating manufacturers to provide graduations which are visible throughout a much longer period of use in alkaline solutions.

Photographic Graduates (PH4.9-1956). This defines requirements such as (a) accuracy, (b) nature of the construction material, (c) design of the pouring lip, to allow the graduate to be emptied quickly without liquid spreading beyond the lip and emptied slowly without permitting the liquid to run down the outside wall, and (d) legibility and permanency of the graduation marks.

Methods and Criteria for Determining the Chemical Resistivity and Photographic Inertness of Construction Materials for Processing Equipment (PH4.13-1954). The standard specifies test solutions and accelerated test methods for determining the chemical resistivity and photographic inertness of materials of construction for solution containers, solution supply systems, and other equipment intended for contact with the solutions or their vapors in connection with the processing of photographic films, plates, and papers by the usual operations of developing, rinsing, fixing, and silver image bleaching.

Photographic Filing Envelopes for Storing Processed Photographic Films, Plates, and Papers (Z38.8.21-1950). An alarmingly large number of valuable film and plate negatives, as well as color transparencies, now in storage have been ruined by the presence of a streak or stain where the negative was in contact with the pasted seam which has been invariably located in the center of the negative envelope. This stain is a result of one or some combination of the following causes: (a) the combined effect of residual processing chemicals and adhesive; (b) unsuitable adhesive—which may stain by itself or promote fungus growth; (c) poor paper—a low-grade paper will affect an otherwise satisfactory adhesive. This standard was designed with a view to avoiding such stains by locating the seam at the extreme edge of the envelope and defining suitable types of paper and adhesive.

Specification for Photographic Grade Dry Mounting Tissue (PH4.21). This standard, in process of approval, defines such characteristics as thickness and nature of the adhesive coating, activation temperature, and blocking (adhesion) tendency.

Specifications for Photographic Laboratory Spring-Driven Timers (PH4.25). The standard, in process of approval, defines (a) timers measuring continuous elapsed time, and (b) those measuring a pre-set interval of time both of which shall provide visual and/or audible indication of the time interval.

Requirements for Photographic Grade Blotters (PH4.10-1953). Defines the requirements for photographic grade blotters in which impurities known to be photographically harmful are limited to a safe quantity. The chemical tests and analyses are intended to indicate the presence of photographically detrimental impurities which might occur in the production and supply of the blotter materials.

Specification for Chromium-Plated Surfaces for Ferrotyping (Z38.8.18-1948). This standard covers both plated sheets and plated drums for ferrotyping and defines the nature of the polished surface and its wear and corrosion resistance.

International Standardization

The ASA is Secretariat for the ISO Technical Committee 42 on Photography of the International Organization of Standardization. At a meeting of ISO/TC 42 in Stockholm, Sweden, June 6-10, 1955, it was recommended that the following standards developed by Sectional Committee PH4 be adopted as International Standards:

ISO/TC 42 (18)—Method for Determining Thiosulfate in Processed Photographic Film (Part I), and Method for Determining Thiosulphate and Tetrathionate in Processed Photographic Papers (Part II).

ISO/TC 42 (19)—Method for Indicating the Stability of the Images of Processed Black-and-White Films, Plates, and Papers.

ISO/TC 42 (20)—Specification for Photographic Grade Hydroquinone.

ISO/TC 42 (21)—Specification for Photographic Grade Mono-Methyl-Para-Aminophenol Sulfate.

ISO/TC 42 (22)—Specification for Photographic Grade Potassium Bromide.

ISO/TC 42 (23)—Specification for Photographic Grade Sodium Carbonate, Anhydrous.

ISO/TC 42 (24)—Specification for Photographic Grade Sodium Sulfite.

ISO/TC 42 (25)—Specification for Photographic Grade Sodium Thiosulfate, Crystalline.

These standards have been circulated to the various member bodies for comment.

Future Work

Apart from the constant necessity for revising existing standards, the increasing use of color in all branches of photography will necessitate special attention to the processing of color materials.

Work on a number of organic chemicals for color processing is well underway and, in view of the trend to mechanization of processing procedures, it is hoped that early standardization of those aspects which, if not made universal, might otherwise cause confusion will be effected.

Not the least beneficial value of the work of Sectional Committee PH4 has been the harmony of collaboration between representatives of the various photographic concerns working for the good of all. If the committee had accomplished nothing more than to integrate some of the processing procedures of the several manufacturers into common recommendations, its work has been worth while.

References

1. Agnew, P. J.: "Standardization," Encyclopedia Brittanica.
2. "The Organization and Work of ASA Sectional Committees," PR 27, American Standards Association, Inc., 70 East Forty-fifth St., New York 17, N. Y.
3. "How American Standards are Developed and Approved," PM 125, American Standards Association, Inc., 70 East Forty-fifth Street, New York 17, N. Y.
4. "Standard Quality of Photographic Chemicals to Improve Picture Processing," Carroll V. Otis, Standardization, January 1949, pp. 10–14. "American Standards for Color Finishers," R. J. Wilkinson, Phot. Sci. & Tech., August 1956, Ser. II, Vol. 3, No. 3, p. 119.

A MICRODENSITOMETER FOR REFLECTING SAMPLES*

Joseph H. Altman and Keith F. Stultz

ABSTRACT

This paper describes a microdensitometer for reflecting samples in which the sample is illuminated with a Leitz Ultropak Incident-Light Illuminator and curves of density *versus* distance are recorded by a Brown (Electronik) Recorder on rectangular coordinates. The sensitivity of the system is sufficient to scan color print materials through the required filters. Resolution is 500 lines/mm on a test grating, and the stray light is estimated at 2.0 percent.

A RECORDING MICRODENSITOMETER capable of accurately analyzing reflecting samples is essential for studying the structure of photographic images printed on paper. Although some transmission microdensitometers may be converted to reflection operation by illuminating the samples with incident light, extreme precision can be obtained only with an instrument specifically designed for use with reflecting samples.

Recently, a transmission microdensitometer was constructed which met the severe performance requirements of photographic research.[1] The present paper describes a reflection microdensitometer based on the experience gained with the transmission instrument and intended to approach the same performance level. It is illustrated in Figure 1.

Design of the Microdensitometer

Two aspects of design that were found helpful in the operation of the transmission microdensitometer have been applied to the present instrument. These are:

(a) Standard microscope optics operating at a higher optical magnification than is common in other microdensitometers; and

(b) An individual calibration for each sample, in which the recorder deflections of a series of densities measured in a conventional manner are scanned, providing a scale which is used to determine density variations in the unknown.

Optical features. The optics of the instrument are mainly stock items of microscope equipment designed for use with samples requiring incident illumination. The key optical element is the Leitz Ultropak Incident Light Illuminator[2], which attaches to a standard monocular microscope body tube. This device offers two advantages for the present purpose. First, the light is incident on the sample through the full 360 degrees of azimuth. Second, because the light paths for illumination and viewing are separate, the level of flare light in this system is lower than in some other types of incident illuminators.

The complete optical system is shown in Figure 2. Light is obtained from an 18-ampere, 6-volt coiled-filament lamp. A coiled-filament lamp is used rather than a ribbon-filament because it is both brighter and more compact and thus it approaches a point source, which is desirable for use with the Ultropak Illuminator. The coiled structure of the filament is not perceptible because

diffusion is provided in the condenser system to ensure even illumination of the sample.

Light from the source, after being collimated by the lamp condenser, enters the Ultropak unit through an afocal illuminating attachment, also made by Leitz, and is directed to the sample by the condenser portion of the Ultropak unit. The combination of the Ultropak objective with a 12× ocular in the upper end of the body tube thus forms a compound microscope, which is used to project an enlarged image of the sample onto a screen placed at such a distance from the ocular that the final magnification of the image is 200×.

The scanning aperture consists basically of a slit cut in this screen, and its effective size at the sample is its physical size divided by the optical magnification. Actually, however, this aperture is more complex, since both its width and its length are adjustable. Its length
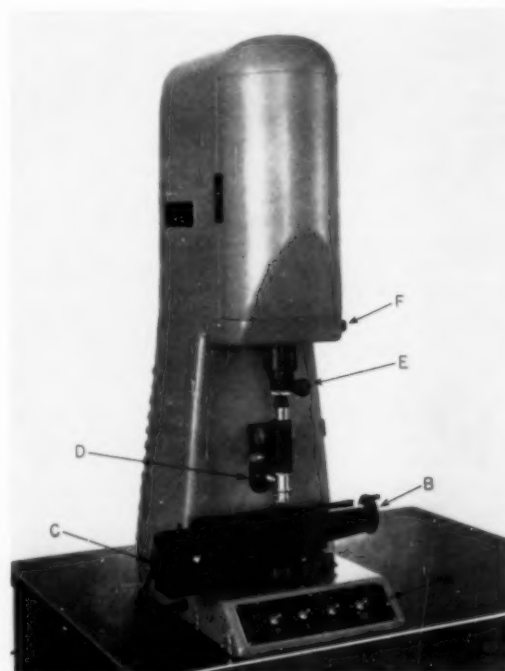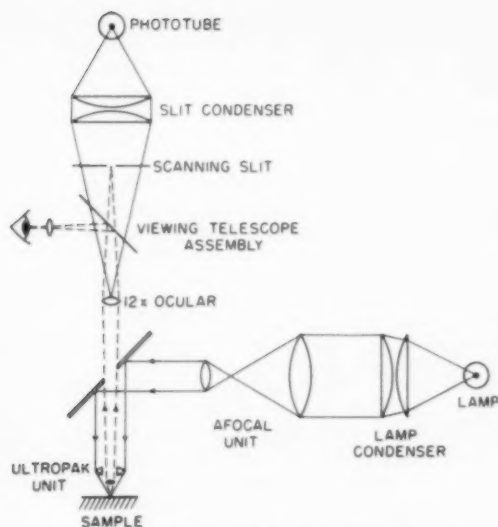

Fig. 1. General view of microdensitometer: A, controls; B, carriage-drive assembly; C, motor and speed reducer; D, afocal illuminating condenser; E, viewing telescope; F, slit-width control knob.

Fig. 2. Optical system of microdensitometer.

on the sample can be varied in steps by a sliding mask so that the length of its image varies from 50 to 400 μ. Its width is continuously adjustable from zero to 20 μ.

The slit condenser, mounted immediately behind the slit, images the exit pupil of the microscope on the cathode of a photomultiplier tube.

For convenient and accurate operation, it is necessary that the operator be able to inspect the image formed by the scanning microscope. Such inspection is accomplished by fitting to the body tube a viewing-telescope unit consisting of a secondary ocular and a partially silvered prism. By swinging this prism into the beam, the operator can see the same image that is projected on the main slit. Ordinarily, the prism is swung out of the beam during the scanning operation to avoid contributing to the stray light, but it can be left in the beam for continuous observation of the image.

Ultropak units of various focal lengths are available, and the angle of incidence is different for each one. The unit used in the present instrument sends the light to the sample in a hollow cone whose boundaries make angles of approximately 39 and 45 degrees to the viewing axis. The objective, which has a focal length of 16mm, provides an initial magnification of 11×. The numerical aperture is 0.25, so the sample is viewed with a half-cone-angle of 14.5 degrees. The departure of this illumination system from the recommended standard will be discussed in the next section.

Mechanical Features

The mechanical construction can be seen in Figure 1. Scanning is accomplished by driving the sample past the measuring aperture at a rate depending on the nature of the sample and the scale desired for the record. The carriage-drive assembly B provides a 6-inch sample travel by means of a lead screw having a 1-mm pitch. A vacuum frame with supplementary spring clips is provided to hold the sample flat on the bed.

Provision is made for rotating the entire linear drive assembly about the optical axis of the instrument and for transverse motion to locate the sample area to be scanned.

The gear reducer provides seven reduction ratios that may be chosen by turning a knob. The available sample speeds vary in steps of 4× from 100 to 0.0245 mm/min. Reversing gears and a neutral position are also provided. These are external to the reducer proper, and the motor and reducer always run in the same direction. This eliminates the delay which would be caused by backlash in the gears if the motor were reversed.

The scale of the record is determined by the relative rates of sample and recorder paper. The recorder associated with the equipment provides chart speeds of from 2 to 8 in./min., and therefore speed ratios from 0.5× to 8320× are available.

Electrical features. The amplifier, which is shown in Figure 3, responds logarithmically and is based on a circuit patented by Gunderson.[3] The principle of the circuit is that, when the anode current of the photomultiplier tube is held constant, the variation in cathode potential is essentially logarithmic with variations of the incident light flux. The output of this circuit is fed to a Brown (Electronik) Recorder, which thus plots the logarithm of the intensity of the light reaching the photomultiplier tube.

Performance Characteristics

Calibration. Of first importance in evaluating the performance of the instrument is its ability to measure density. The circuit employed to obtain a logarithmic response has previously been shown to be both stable and linear in density over a wide range, if sufficient light is available. With the present illumination system, it is possible to measure color densities up to 2.2 through a 2-μ slit and through a Kodak Wratten Filter No. 29, 47B, or 61. There is, of course, ample sensitivity for any density obtained with silver images.
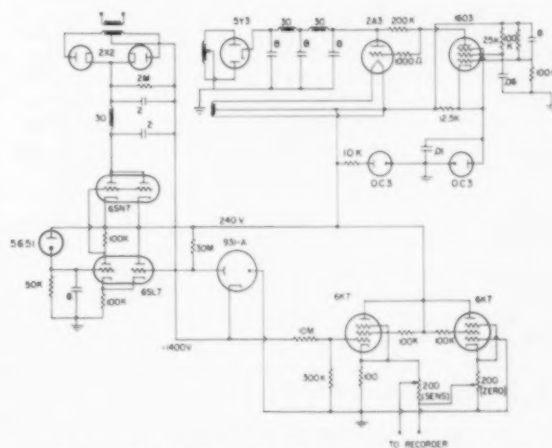

Fig. 3. Simplified wiring diagram of the microdensitometer. The battery of dynode resistors, which is connected in series from the phototube cathode to the ninth dynode(ground) is not shown.
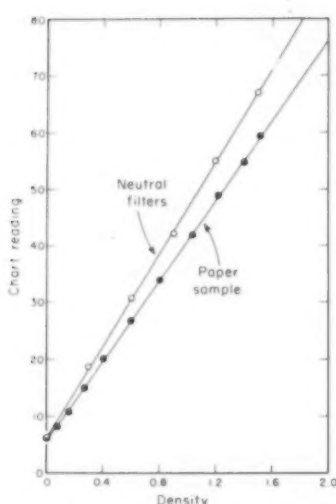
11

Fig. 4. Test of microdensitometer. If the instrument read reflection density in the standard manner, the curves would coincide. See text for the method of avoiding this difference.

Although the instrument uses normal viewing of the sample and nearly 45-degree incident-illumination, it differs from the recommended standard system[4] because the incident beam is not symmetrical about 45 degrees and because the pickup cone angle is quite large. In order to appraise the departure of the system from the standard, a paper step tablet calibrated in a conventional instrument was scanned. The resulting plot of recorder deflection *versus* density is shown in Figure 4. A similar curve was then run with neutral filters placed in the illuminating beam. The difference between these two plots indicates the departure of the Ultropak system from the standard. By decreasing the size of the pickup cone with funnel stops in the objective, it was found possible to bring the system closer to the standard, but the standard could not be matched exactly.

It is important to note, however, that the use of the calibration technique by-passes this difficulty. As long as the calibrating sample has the same reflecting characteristics as the unknown, the density values of the unknown are accurately given in terms of the calibration densities. This has been checked, of course, by direct experiment.

Resolving power. Also of interest in appraising the performance of the instrument is its resolution, which is a measure of its ability to analyze images in detail. Resolution was checked with a Grayson ruling[5] as a reflection test object, and it was found that, with the 16mm objective and a $0.3\text{-}\mu$ slit, a resolution equal to 500 lines/mm could be recorded.

Stray light. The basic method for determining the level of stray light in a microphotometer is to scan a narrow, infinitely dense line on a bright field. With transmission instruments, a fine wire serves; for the present instrument, a suitable test object was made by cementing two pieces of white paper parallel to each other and some 100μ apart on a piece of black plane-polished glass.

Although this is, of course, an arbitrary standard, it served to give some idea of the level of stray light in the instrument. When the black glass was measured alone, its density was greater than 3.0 in the instrument. When measured with the white paper in place, the black-glass area had a density of 1.71, indicating a stray-light level of slightly less than 2.0 percent. If the viewing prism is left in the beam, the stray-light level is measurably higher.

Although this is a comparatively high stray-light level, it is to some extent inevitable, since the sample is, after all, visible only because of scattered light. On the other hand, the reflection instrument has no field slit, which experience with the transmission microdensitometer has shown to be very useful in the control of stray light. It is, however, impossible to image a field slit on the sample with the present illuminating unit.

While the error introduced by stray light is appreciable in the special test object, its importance diminishes rapidly when the fine line is less dense or when the dense area fills more of the field. Since both of these conditions almost always exist for practical samples, the comparatively high stray-light level is not very significant in practice.

References

1. J. H. Altman, K. F. Stultz, "A Microdensitometer for Photographic Research," Rev. Sci. Instr., vol. 27, p. 1033, 1956.
2. H. Heine, "Der Ultropak," Z. wiss. Mikroskopie, Vol. 48, p. 450, 1931-32.
3. N. R. Gunderson, U. S. Patent 2,454,871 (1948).
4. Proposed American Standard for Reflection Densitometry, American Standards Association, Incorporated, 70 East Forty-fifth Street N. Y. C. April, 1956.
5. E. W. Stone, "Grayson's Micro-Rulings," J. Sci. Instr., Vol. 11, p. 1, 1934.

AUTOMATION IN THE THEATRE

A British audience recently watched what may prove to have been a revolutionary film show. Unknown to them, a robot machine was in control of the projection booth. This switched on the lights, opened the curtains, and regulated the sound. The projectionist had nothing to do but mark the film, load it onto the projector, and set the unit, according to the British Information Services.

The equipment, manufactured by G.B.-Kalee Ltd., Mortimer House, 37-41 Mortimer Street, London, W.1, and called the Projectomatic System, is designed to perform automatically the main operating functions associated with a continuous motion picture theater performance. The sequence in which the various functions are carried out is determined by the arrangement of pins set in a rotating drum, or, in the case of change-over operation, by marks on the film. Once the drum has been set up and the film marked, prior to the first performance, the show will run continuously without further action by the operator other than to clean and thread the projectors, renew carbons and change discs. There is even an emergency stop circuit in the event of a film break or mechanical failure.

This basic unit will start, stop and change over the projectors; open and close the curtains; switch on and off the footlights; and control the non-sync. The most comprehensive installation will operate in addition: magnascopic masking for three positions; change over for $^3/_4$ track sound; and operate a color selector for footlights or houselights.

A NEW APPROACH TO PHOTOGRAPHIC APPARATUS TESTING

S. L. Love and L. L. Blackwell*

ABSTRACT

A variety of methods used for testing photographic equipment are briefly discussed. A coordinated, single instrument of the cathode ray tube type is described, which simplifies the analysis of the action of many types of photographic equipment. Various functions are incorporated which make it possible to analyze shutter efficiency and operation, contact operation, motion picture equipment operation and other actions, using a simplified, step-saving approach.

IN TRAINING PEOPLE to service photographic equipment, the National Camera Repair School recognizes that a most important feature of any manufacturer's service department or camera repair shop is adequate test equipment. The manufacturer's needs and the serviceman's needs are usually widely separated. To coordinate these needs, to interpret them and to develop instruments which would meet manufacturer's standards of accuracy and dependability as well as servicemen's standards of ease-of-operation and moderate cost, have been the aims of this school. The problem of engineering development of a single instrument which offered the brightest possibilities under the extremes of laboratory and field conditions offered a challenge which has been solved in an interesting way.

Some Present Test Instruments

Test instruments in use by camera manufacturers and by various service organizations for the mechanical and electrical testing of photographic equipment fall into a number of distinct categories. Some of these may be classified as follows:

1. Instruments employed to test shutter action and exposure duration.
2. Instruments designed to test flash synchronization.
3. Instruments designed to test shutter contacts or other electrical contacts.
4. Instruments designed to test motion picture equipment for exposure duration and operating speeds, or picture sequence time interval.
5. Instruments used to check amplifier circuits.
6. Instruments designed to test miscellaneous variables such as flashbulb output, exposure meter accuracy and battery power.

A variety of testing equipment has been built in the past to perform these various tests. In manufacturer's laboratories and servicing departments, single purpose instruments often are individually designed and built to suit a specific need. From the apparatus built by P. G. Nutting for the Kodak Laboratories,[1] which produced a series of images of between-the-lens shutter blades made at accurately measured intervals, to modern production test techniques involving oscillators and electronic counters, there have been many stages in the

* National Camera Repair School, Inc., Englewood, Colorado. Received 14 January 1957.

development of shutter testing instruments. The standard oscillograph testing method prescribed by American Standard PH3.4–1952 marked a step in this advance which has seen the adoption of several means of translating light transmission by a shutter into a calibrated capacitor charge, thus integrating the total shutter action to arrive at a true exposure rating; as well as many improvised methods involving the photography of moving objects having known image velocity.

For testing flash synchronization, probably the most successful technique has involved the use of a delayed triggering gaseous discharge tube.[2]

Instruments for testing contact efficiency vary from devices which measure the amount of current flowing through a set of contacts during the closure period, or the time of contact closure, to simple qualitative means of testing contact action.

Motion picture equipment testing has been done with devices ranging from stroboscopic instruments to electronic counters arranged in ingenious set-ups.

Flashbulb output tests usually involve complex oscilloscope set-ups plus light-integrating instruments.

It is the usual custom to check exposure meters by means of a calibrated light source or with a comparator arrangement.

Very frequently, instruments have been designed which combine two or more testing functions. Several of these are notable. Many tests can be performed on the laboratory level with oscillographic instruments, proper calibration means and variations in set-up. Instruments of the discharge-tube type, having flashing delay times variable in small increments, can be used to plot, physically or mentally, the operating curves of many types of equipment. In addition, for flash equipment tests, the loads of one or more flashbulbs can be simulated in some instruments in order to predict the action of synchronizer arrangements in practice. The variables introduced by battery exhaustion, flash extension length, and inherent resistances can be imitated or measured.

The shortcomings of many existing test instruments are more or less obvious. Equipment of the cathode ray tube type, although often accurate, become economically unfeasible in smaller service departments. The operation of such equipment is somewhat difficult and cumbersome in practice. Photographs of the cathode ray tube face must be made in order to properly evaluate results. Instruments of the electronic-counter type are quite fast and valuable in production work, but only if the normal action of the equipment under test is known and has been preevaluated on a laboratory level. For example,

electronic-counter instruments do not usually take shutter efficiency into account when measuring shutter speeds and cannot indicate true exposure speeds unless efficiency has been predetermined. Instruments of the flashtube type, in effect, arrest the motion of the equipment at a precise interval after triggering. This makes it mandatory actually or mentally to graph in small increments the action of the equipment being tested. It is difficult to build such instruments with satisfactory reliability and accuracy so that eccentricities of the instrument do not falsify the calculations.

Thus, except in the highest echelons of test equipment (which also have the shortcomings of initial cost, calibration and operating time), it is difficult to answer all of the questions one might ask about the products under test.

Preliminary Considerations

It was apparent that some single instrument that would fulfill many needs would be desirable. The following general specifications for such a versatile instrument were outlined:

1. It should be capable of sustained high accuracy.

2. It should be useful for a number of related tests.

3. It should require a minimum number of changes in set-up when switching from one test to another.

4. It should be an instrument having great range. Modern shutters, for example, operating at exposures as short as 1/2000 second, require a testing accuracy up to 1/10,000 second or less.

5. It should provide immediately intelligible results, without time-consuming photographic manipulations or mathematical calculations. It should, however, be possible to make permanent records of tests if such records are required.

6. It should be sufficiently uninvolved in use so that it would be equally at home in a retail camera shop or in a manufacturer's service department.

7. It should be easily calibrated in the field.

8. It should be moderate in cost to permit repair shops and dealers of moderate means to take advantage of its other desirable features.

Because the graph is the most widely accepted means of expressing relationships between variables, it was felt that the oscilloscope would be the ideal basis for a universal test instrument. From the amateur just becoming interested in flash photography, to the engineer with his intricate technology, everyone is accustomed to interpreting graphs showing flash action, shutter action or other activities in photographic machines.

The prime deterrent to the choice of such an instrument is that oscilloscopes require extensive operator training and, in ordinary form, need external calibration means. The problem, then, was to devise an oscilloscope which would furnish all the needed functions without complicated set-ups or expensive accessory units.

Timing with an oscilloscope is commonly accomplished in one of two ways when motion is being studied.

1. Internal oscillator control markers "pip" the trace at predetermined intervals. Photographs of traces made with these markers in evidence can be thus analyzed but the photograph is essential and the intitial set-up required to provide a sweep of the proper period is complex.

2. In the testing of between-the-lens shutters, an external oscillator can be used to modulate the "Z" signal so that action occurring during the trace can be timed. Again, a photograph of the trace is essential.

An ideal system would be one in which sweep time could be controlled with accuracy and stability, with a minimum number of controls, so that the operator would know exactly how much time is involved in any individual trace. With that ideal in mind a rather unusual sweep circuit for the oscilloscope was evolved that forms the base of the ServiShops Motion Analyzer. The Analyzer's sweep-timing circuit is a thyrotron-controlled saw-tooth generator. Unfortunately, ordinary circuitry that might be introduced to translate a saw-tooth wave into horizontal deflection would materially affect the sweep-time accuracy. Therefore, an electrostatic sweep generator having an impedance on the order of 10^{10} ohms is used to feed the oscilloscope horizontal amplifier accurately without excessive external controls. The principle makes it possible to use small capacitors and large resistances in the R-C circuit and still obtain accurate time variations through virtually any range.
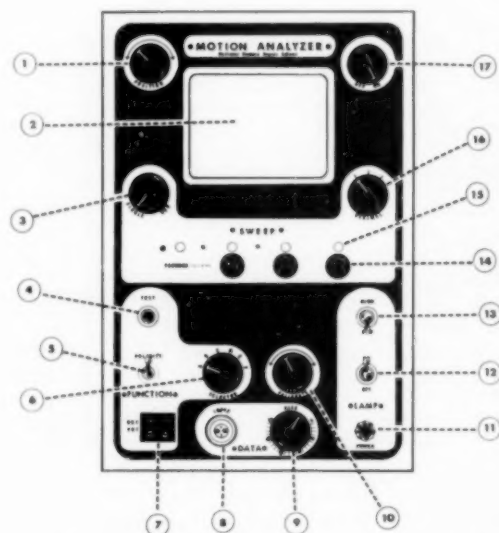
Fig. 1. Control panel of the Motion Analyzer. Key to diagram: (1) Horizontal POSITION control, (2) SCREEN, (3) SINGLE-RUN switch, (4) FUNCTION Test button, (5) FUNCTION OUTPUT POLARITY switch, (6) FUNCTION SELECTOR switch, (7) FUNCTION OUTPUT terminal, (8) DATA INPUT terminal, (9) DATA RISE control, (10) CALIBRATE control, (11) LAMP POWER terminal, (12) LAMP ON-OFF switch, (13) LAMP HIGH-LOW switch, (14) Three DIGIT CONTROL knobs, (15) OPENINGS where SWEEP time in seconds appear in illuminated figures, (16) DECIMAL point position switch, (17) MASTER switch.

Fig. 2. Arrangement of electrical components in the Motion Analyzer. A selection of simple component circuits is provided for a variety of applications.

The result is an oscilloscope with sweep times calibrated in total time per sweep, rather than in centimeters per second. By choosing from among three capacitors (which choice determines the position of the decimal point) and 27 resistors, sweep time may be varied from le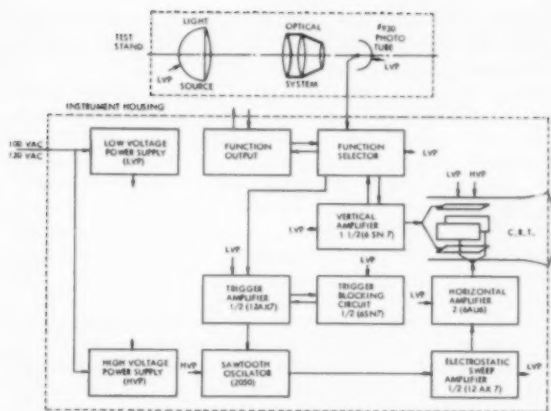ss than .0010 second to 9.99 seconds. Because of the basic stability of the R-C constant, the sweep can "run" with little variation, without synchronization.

Figure 1 shows the Analyzer controls and the block diagram in Figure 2 indicates the arrangement of the components electrically. After the basic idea was developed, it was only a matter of adding controls and operating methods in order to provide versatility for the applications needed. For example, a single-sweep trigger system is included with a variety of permissible combinations between triggering and deflection signals. Vertical deflection alone can trigger the sweep. The input from a phototube or other transducer can be used for triggering action alone, or in combination with vertical deflection. A trigger-blocking circuit prevents all but the first impulse from initiating the sweep. This permits several pulses during a single transient action to be studied and timed. To test such actions as contact closure, the initial contact closure can be used to trigger the sweep, simultaneously causing vertical deflection. For recurrent actions, the sweep can be set to run at the period of recurrence.

Units and Controls

The instrument itself is housed in a cabinet approximately $8^7/_8 \times 15 \times 17^3/_4$ inches in size. In addition to the basic instrument, a Universal Stand is used to support a sealed beam lamp plus a housing containing an optical system and a phototube. For many tests involving photographic equipment, light can be modulated to indicate the action of the device under test. Controls on the Analyzer permit the lamp to be used at full or half intensity. Using the lamp at full intensity, it is possible to examine such actions as a between-the-lens shutter operating at an aperture of $^1/_{32}$ inch. A set of controls on the Analyzer itself change the sweep time

directly. The sweep time is calibrated in seconds and is read from illuminated figures across the front of the instrument panel. A secondary sweep-time control changes the position of an illuminated decimal point among the figures displayed on the Analyzer panel. Six positions of the function selector switch permit a variety of relationships between triggering of the trace and vertical deflection.

The Analyzer may be operated as follows: A spot of light appears on the left side of the screen and travels from left to right in a variable period of time, depending on the setting selected by the operator. The time interval possible can be varied from .0005 second to 9.99 seconds. At short time intervals, the spot travels so rapidly that it appears as a line traced on the screen. The time required for the post to travel across the screen appears in the illuminated figures on the panel of the instrument. The figures are easily read and quickly changed. The reading is in seconds and the illuminated decimal point may be switched quickly to cover three broad ranges.

Ordinarily, the spot of light will travel in a straight line, horizontally, from left to right. Either one of two factors, depending on the operator's choice, will cause the spot to rise during the period in which it is traveling across the face of the cathode ray tube:

1. Light falling on a phototube (or power provided to the data input by any other transducer), or

2. An electrical impulse flowing in or out of the instrument to the function output.

Data input may be provided in several ways so that the vibration of a unit being tested, battery power, or virtually any electrical power applied to the Analyzer, as well as contacts of any kind closing to complete a circuit from the function output, can cause vertical deflection of the moving spot.

Once the time interval is set, using the three digit control knobs and the decimal control, the sweep can either run free or travel across the screen only when desired, at the operator's discretion.

When the spot is running free, it will sweep from left to right across the screen in the interval of time that is chosen and then return to the left side of the screen very rapidly to repeat the performance indefinitely. Under such conditions, if the sweep time is set at a period of, perhaps, 0.100 second, the spot will travel across the screen ten times each second, and continuously.

When the Analyzer is set for single sweep, a variety of triggering methods is available to put the spot into motion. For example, power applied into the Analyzer can be used to trigger the movement of the spot. By combining the various functions of the Analyzer it is easy to analyze and measure such things as:

1. Shutter action of all kinds: a. Time required for the shutter to operate during any single phase or group of phases.

2. Contact action: a. Efficiency of contact closure. b. Dwell time. c. Bounce and other eccentricities in contact action.

3. Synchronization or time interval between various actions: a. Time between contact closure or current flow and shutter opening. b. Time between initiation of an action and its completion.

4. Effectiveness of battery-operated synchronizer units or photographic flash equipment, and the changes

that take place when variations in the arrangement are made or occur. a. The load equivalent of one or two flashbulbs may be placed on the batteries at the same time that the synchronizer is being used to operate the shutter. In these instances, changes are clearly visible.

Moderate accuracy in the adjustment of solenoids or other electrically-operated units may be obtained when using power available from the ServiShops Analyzer.

Motion Picture equipment or any equipment with a repetitive type action may be timed with the Analyzer. Projector and motion picture camera governors may be set within any limits of accuracy desired. (The instrument can be calibrated to an accuracy of plus or minus one percent.)

Virtually any rotating, reciprocating or other constant movement may be timed accurately.

The Analyzer controls are somewhat limited and easy to operate. They consist basically of Sweep setting controls, spot Position controls, and Function controls. The controls will be mentioned individually and described briefly.

Master Switch. The master switch at the upper right corner of the panel turns the Analyzer on or off. However, when the instrument is plugged into a wall socket and turned off, a portion of the Analyzer operates at a reduced or "standby" voltage. Because of the standby condition, the warmup period of the Analyzer is quite short and within a few seconds after turning on the master switch the instrument is ready for use. This permits the instrument to remain in a "ready" condition, simultaneously increasing the life of the instrument's components and reducing current consumption. If the instrument is not to be used for a period of 12 or more hours, it is recommended, but not necessary, that it be unplugged from the socket. The decimal point glows only when the Analyzer is on.

Terminals. There are three terminals on the face of the Analyzer. The photocell unit plugs into the special polarized jack (Data Input) at the lower center of the instrument panel. A pair of ordinary "convenience" outlets (at lower left) are used for providing current from the instrument or passing current into the instrument. Into this Function Output may be plugged the leads from contacts or flashgun—or any power source under test. The ordinary 'phone jack at the lower right of the panel provides controlled power for the sealed beam lamp.

Time Interval Setting Knobs. Four knobs are turned to set the time required for the spot to move from left to right on the screen. Three switches, with ten positions each, set up the digits for the time interval. A three position switch controls the position of the decimal point among those three digits. The left-hand digit switch, depending on the position of the decimal point, represents either hundredths of a second, tenths of a second, or seconds. The central digit switch with corresponding positions for the decimal point, represents thousandths of a second, hundredths of a second or tenths of a second. In like manner, the right digit switch represents either ten-thousandths of a second, thousandths of a second or hundredths of a second. Thus, with the three digit switches all set on 6, the position of the Decimal point only would determine whether the sweep time would be .0666 second, 0.666 second or 6.66 seconds. The numbers glow in the panel whenever the Analyzer

is plugged in—and the decimal position that is chosen is indicated because the point lights up as soon as the Analyzer is turned on.

Single-Run Switch. This two-position switch determines whether the spot will move from left to right only when triggered by some external means, or whether it will repeatedly continue to move from left to right, returning to the left at the end of each sweep. Usually, the single sweep type trace is used to examine "transient" activity, such as a shutter which opens and closes once during a cycle or a pair of contacts which close and open once during a cycle. Running traces are used to time activities which repeat themselves regularly. Thus, the run position would be used for analyzing such equipment as motion picture cameras and projectors. This position is also useful when it is necessary to observe a steady vertical deflection of the spot, such as would result when using the Analyzer as a master meter to test photoelectric exposure meters.

Horizontal Position Control. This control, at the upper left of the instrument panel, is used to adjust the position of the sweeping spot so that it will be framed properly on the screen when making an analysis.

Function Select Switch. The position of the Function Select Switch determines: a. What will trigger the sweep when the Analyzer is set in the single sweep condition. b. What will deflect the spot vertically.

There is a six-position select switch and one test button in the Function group at the lower left of the Analyzer. Each of the select switch positions will be described individually.

A. In this function, the ServiShops Analyzer is triggered by an increase in the voltage fed into the data input terminal. Thus, if a shutter is used to block the light striking the photocell, the sweep will be triggered as soon as the shutter starts to open. In addition, the rise of the spot is determined by the amount of light striking the phototube. In operation, the sweep and vertical rise of the spot combined will graphically illustrate the action of the shutter.

B. Triggering the sweep in this position is accomplished by completing a circuit from the function output terminal. At the same time, a rise in the spot is the result of the current flowing through the contacts. Thus when the contacts close, the spot will rise—and when the contacts open the spot will drop. During any interval chosen, it is possible to see how well a pair of contacts close, how long they remain closed, and whether the action of the contacts is steady or erratic. The initial contact triggers the Analyzer. During the sweep, the spot will remain high as long as the contacts remain fully closed.

C. With the select switch in this position, the Analyzer supplies power from within and the sweep will again be triggered when the function output circuit is completed through any external contacts. This position is used for testing flash synchronization or any other action where the sweep should be triggered by closing contacts. The rise of the spot is determined either by light striking the photocell or by other voltage applied to the data input terminal. Thus, when testing a shutter with internal contacts, the sweep can be triggered by closing the contacts, but the spot will not rise until the shutter opens and/or light strikes the phototube.

16

D. This position is used almost exclusively for the testing of solenoids. For such tests, a solenoid is connected in series with the Analyzer function output terminal. When the test button is then pressed, current equivalent to three batteries operating a Heiland-type solenoid will be supplied to simultaneously trigger the sweep and operate the solenoid. A battery case may also be connected in parallel with the solenoid so that synchronization testing can be done with the normal set-up. Vertical deflection is again caused when light reaches the phototube or when other voltage is fed to the data input terminal.

E. This function is selected for general synchronization testing when it is desirable to know how the batteries will fire the equivalent of one flashbulb. The flashgun is attached to the Analyzer exactly as in function D. Thus, external power with a small load is used to trigger the instrument in this position. Rise in position E is again determined by the amount of light which reaches the phototube.

F. This position is the same as function E, except that the load placed on the external power source is equal to two flashbulbs. The difference in synchronization which occurs when a flashgun is used to fire either one or two flashbulbs is thus readily apparent.

The Data Rise Control. This control, at lower right center of the Analyzer panel, determines the distance the spot will be deflected vertically, depending on the amount of light striking the phototube or the amount of voltage being applied to the data input terminal. For a fixed voltage, the further clockwise the control is turned, the higher the spot will rise.

Lamp and Photocell. For greatest convenience, a phototube and optical system are housed in a cabinet and mounted on a Universal Stand, which also carries a high-efficiency sealed-beam lamp unit. Although any light source may be used, from the extremes of a candle or flashlight to the sun, the stand and sealed-beam lamp are quite handy. Other light sources regularly suggest themselves for special tests. For example, the light source from a motion picture projector may be used for timing that projector. Any lamp may be used as a master light source when setting up the Analyzer as a master photocell for the testing of photoelectric exposure meters. Once the exact rise is determined (with the instrument set on "run") for a given number of foot candles of illumination, any meter may be compared with any light source, using the Analyzer.

The Lamp is plugged into the power socket in the lower right corner of the Analyzer panel. One switch in the Lamp Group turns the lamp on and off, while the High-Low switch provides bright or dim light for different tests. In general, it is wise to use the lamp on the low setting except when testing focal-plane shutters at high speed or between-the-lens shutters at small apertures. The internal circuit of the Analyzer prevents the phototube from becoming *saturated*, but the accuracy of the data provided by the phototube is improved when the amount of light is kept to a minimum.

The Optical System in the phototube housing is designed so that a maximum amount of light is gathered. The opening in the photocell housing, through which the light passes, is large enough for virtually any piece of photographic equipment, including large aerial cameras.

The stand may be easily moved, placed on its back or in any other position. A variety of masks may be slid into place to change the shape or size of the opening. For example, a slit may be used to simplify the measurement of focal-plane shutter speeds. The masks are ordinary film-holder dark slides, so that special sizes or shapes may be made for unusual needs.

The photocell housing may be moved up or down on the universal stand without adjusting any nuts or loss of time. It is merely tilted to move it up or down to the desired position. When the housing is returned to the horizontal position it will remain in the position chosen. A series of notches on the stand uprights provide a number of fixed positions for the housing.

In addition, the phototube housing may be completely separated from the stand in order to use it with other light sources or in special set-ups. For convenient use, the Analyzer itself may be placed on a shelf, out of the way. It is convenient to watch the screen and adjust the controls, without wasting any bench space. The Universal Stand, on a bench or table of ordinary desk height, requires a space less than one foot square.

Stability and Calibration

Stability of the Analyzer is of such high order that the unit can be calibrated by impressing readily available standards, like a 60 cycle AC sine wave or the signals from the National Bureau of Standards Radio Station WWV.

In Function A, pressing the test button impresses on the screen the sine wave of the alternating current being used to operate the instrument. Since the alternating current supplied in the average community is accurately controlled, this is a very dependable standard for checking the instrument. With the sweep time set at .0500 second, for example, three stable sine waves appear.

If the three sine waves drift to either the right or left, the sweep time may be corrected precisely, at that range, by turning the Calibrate control to steady the trace.

A single sine wave, similarly, will appear when the instrument is sweeping at .0166 second. Other periods may be checked at $1/4$, $1/2$, 2, 4, etc., sine waves. Longer periods may be checked by comparing a number of sweeps. For example, at a setting of 9 seconds, the instrument should sweep 5 times in 45 seconds, or for an extreme—100 times in 15 minutes!

Production instruments, calibrated at one range may vary up to 5% at some other and extreme range, but calibration is so rapid that the accuracy desired is readily available.

Typical Test Appearance

If it is desired to test a between-the-lens shutter, operating at 1/250 second, the operator would first set the sweep-time to 10 milliseconds, or about twice the anticipated time required for the shutter to operate. By placing the shutter on the photocell housing so that light will reach the phototube when the shutter operates, and then tripping the shutter, a trace like trace 2 in Figure 3 will appear on the Analyzer screen.

As soon as the shutter trips, the Analyzer is triggered. The rising slope of the line "O" indicates the opening
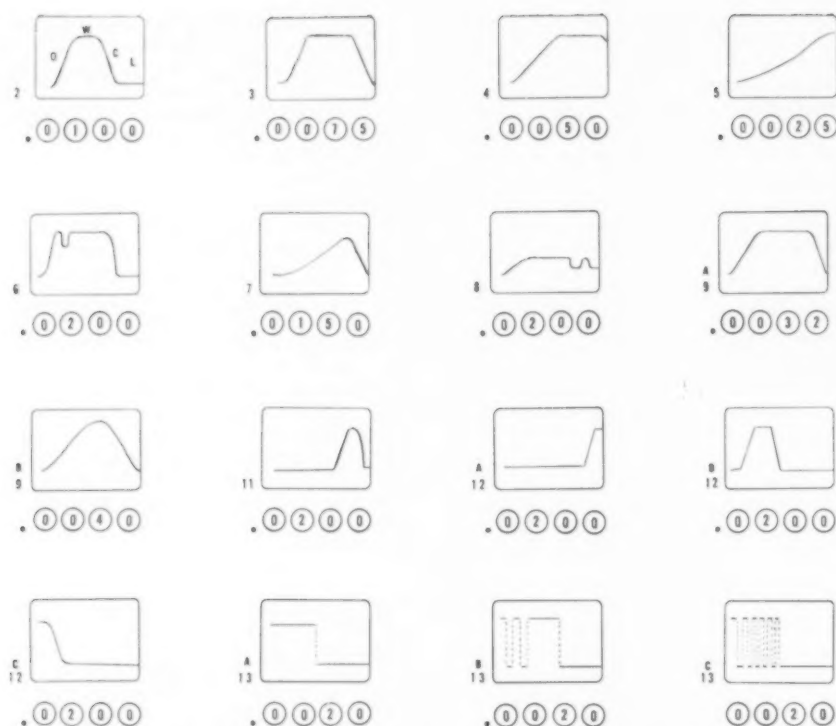
Fig. 3. Typical traces produced by the Analyzer. Trace 2, upper left, analyzes a between-the-lens shutter with O indicating the opening time; W, the open period; C, the closing time. Trace 3, represents the same shutter after the sweep time has been decreased to .0075 seconds operating time. Decreasing the sweep time to 5 milliseconds results in the curve shown in trace 4.

of the shutter. The horizontal line "W" represents the period during which the shutter remained wide open. The downward sloping line "C" indicates the closing of the shutter. The horizontal line "L" from the point at which the shutter closed, over to the right edge of the screen, shows that the shutter was closed for the remainder of the sweep time set on the Analyzer.

If, after decreasing the sweep time, retripping the shutter results in a trace like that shown in trace #3, the total operating time of the shutter can be read as .0075 second.

It is possible to estimate, by observing the trace on the Analyzer screen, how much time is involved during the shutter's opening or closing times. These phases can be precisely measured by, first, decreasing the sweep time to 5 milliseconds, at which point a trace like that shown in trace #4 will be visible on the screen. Such a trace illustrates that the shutter started to close at the end of 5 milliseconds. By decreasing the sweep time to $2^{1}/_{2}$ milliseconds, a trace like that in trace #5 might result, indicating that the shutter required $2^{1}/_{2}$ milliseconds to open.

Many shutter idiosyncrasies can be examined effortlessly because of the ease with which the sweep time may be changed and the controls adjusted on the Analyzer. For example, trace #6 shows the graph traced by a shutter having poor leaf lever control. The trace illustrates that the shutter leaves open fully, bounce

partially closed, and then reopen for the remainder of the exposure. Trace #7 illustrates the graph traced by a shutter having uneven opening and closing times. In this case, the shutter takes a great deal of time to open, but closes quickly.

Shutters with blade bounce can be detected merely by stopping the diaphragm down as far as it will go and choosing a sweep time 7 or 8 milliseconds longer than the total operating time of the shutter. Trace #8 shows the graph produced by a shutter having shutter blade bounce.

Efficiency comparisons and measurements are, of course, nicely made. Trace #9 shows the graphs traced by two shutters, each set at 1/500 second, but having widely different efficiency characteristics.

Because of the variety of triggering methods possible with the Analyzer, synchronization tests are made with a minimum of set up and interpretation time. A typical flash synchronization set-up is shown in Figure 4 and the trace provided by such a set-up with a shutter operating at high speed and *out* of "synch" is shown in Figure 3, trace #11. Without changing the sweep time, which may remain at .0200 second for most synchronization tests, traces #12A, 12B, and 12C show respectively, good synchronization for class M, class F and class X flash.

Contact dwell time, contact bounce and contact efficiency are clearly indicated and promptly analyzed

with this instrument. Traces #13 A, 13 B, and 13 C show the graphs obtained from three different sets of "X" contacts in three different shutters operating at high speed. In each case the contact total dwell time is approximately one millisecond with the sweep time set at two milliseconds. Trace #13 A shows good contact, 13 B shows initial contact bounce and 13 C shows poor contact. A quality indicated in trace #13 B or better, is desirable when such contacts are to be used for extensive flash work.

Technical Specifications for Functions

Function A. Power fed into the data input by a phototube or other transducer will trigger the pulse and cause vertical deflection. Used primarily for shutter speed, vibration or pressure testing. With the sweep in the run condition, this function is used for measuring rotational speeds with input data as a modulator.

Function B. Closing contacts in series with the function output will trigger the sweep and cause vertical deflection. Used for testing contacts of all kinds, either transient or repetitive, and low voltage power sources.

Function C. Contacts in series with the function output trigger the sweep, but data input causes vertical deflection. This function is used for timing two separate, related actions such as contact closure and rotational movement or shutter operation.

Function D. Used almost exclusively with solenoids. Power from the Analyzer or from a battery case trips a solenoid and triggers the sweep while data input causes vertical deflection. A test button on the instrument itself can be used to trip a solenoid.

Fig. 4. Typical set-up of the Analyzer for flash synchronization testing.

Function E. Used almost exclusively with battery case and solenoid, this function simulates the load of one flashbulb. Triggering and vertical deflection are similar to Function D, without the use of the test button.

Function F. This function is the same as function E, except that the simulated load is equal to two flashbulbs.

HORIZONTAL SWEEP TIME: .0005 to 9.99 seconds, plus or minus 1% with calibration.

POWER REQUIREMENTS: 70 watts, 105 to 125 volts, 60 cycle AC.

LAMP OUTPUT: Low—3 volts AC; High—6 volts AC.

TRIGGER: Sensitivity—$1/2$ volt. Blocking time for given data voltage: 2.5 seconds at 10 volts; 6.0 seconds at $1/2$ volt.

VERTICAL AMPLIFIER: Frequency response—DC to 100 KC. Maximum input voltage—100 V AC or DC. Input resistance—4 megohms (data rise control full clockwise). Input resistance—0 ohms (data rise control full counter-clockwise). Maximum sensitivity—10 volts per inch.

TUBE COMPLIMENT: 1 5BP1 Cathode Ray Tube, 1 6SN7 Vertical Amplifier, 2 6SJ7 Horizontal Amplifier, 2 5Y3 Rectifiers, 1 12AX7 Trigger Amplifier, Horizontal Amplifier, 1 6J5 Trigger Blocking Tube, 1 2050 Thyratron Saw-tooth Oscillator, 1 930 Photo Tube.

Circuit Condition at function output terminals for the various positions of the function selector switch:

Position A. Open circuit.
Position B. 10 volts DC at function output, internal.
Position C. Same as B.
Position D. 10 volts to 500 ohm load, 1.6 amps to 1 ohm load, (supplied when test button is pressed.)
Position E. Input resistance duplicates load of 1 flashbulb.
Position F. Input resistance duplicates load of 2 flashbulbs.

Summary

A cathode ray tube oscillograph with controlled and easily calibrated sweep times provides a base for measurement of many transient or recurring phenomena in photographic equipment. The applications, briefly covered here, are limited only to the extent of the operator's ingenuity. Additional applications using a variety of transducers to provide voltage changes to the data input are easily developed. After choosing the proper transducer, it is only necessary to set the sweep time at the period of revolution or recurrence to examine the activity. By reversing the procedure, the time per revolution—or any period—may be accurately measured.

The Analyzer's total-sweep-time principle can eliminate a major portion of the set-up time required when tests are made with standard oscilloscopes. The simple calibration procedure permits inexperienced personnel to gain the advantage of oscilloscopic accuracy and ease of interpretation.

References

1. "Handbook of Photography," Henney and Dudley, Chapter 5.
2. "The Versatile Gardner Synchrotimer," National Camera Repair School, 1956.
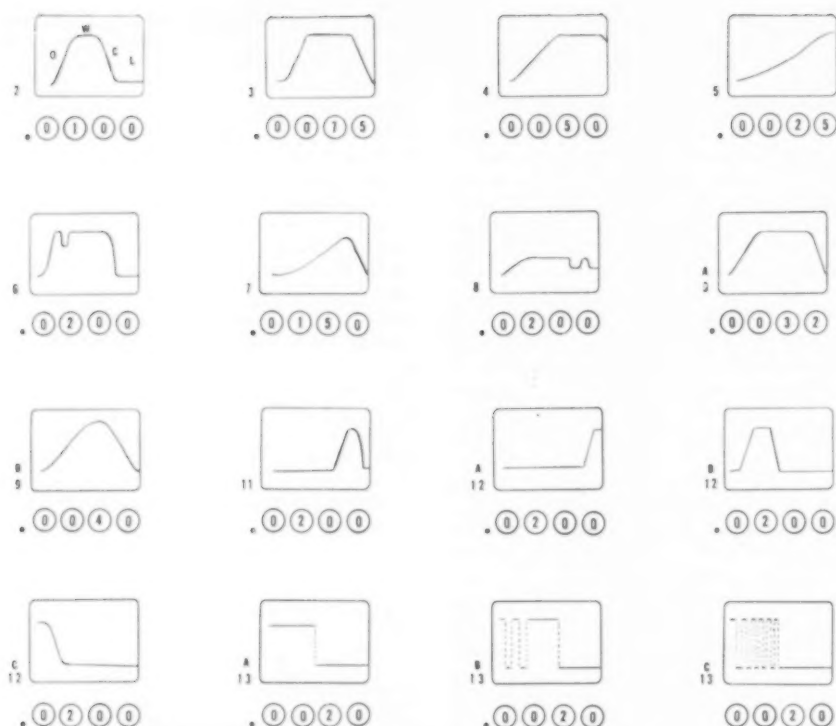
Fig. 3. Typical traces produced by the Analyzer. Trace 2, upper left, analyzes a between-the-lens shutter with O indicating the opening time; W, the open period; C, the closing time. Trace 3, represents the same shutter after the sweep time has been decreased to .0075 seconds operating time. Decreasing the sweep time to 5 milliseconds results in the curve shown in trace 4.

of the shutter. The horizontal line "W" represents the period during which the shutter remained wide open. The downward sloping line "C" indicates the closing of the shutter. The horizontal line "L" from the point at which the shutter closed, over to the right edge of the screen, shows that the shutter was closed for the remainder of the sweep time set on the Analyzer.

If, after decreasing the sweep time, retripping the shutter results in a trace like that shown in trace #3, the total operating time of the shutter can be read as .0075 second.

It is possible to estimate, by observing the trace on the Analyzer screen, how much time is involved during the shutter's opening or closing times. These phases can be precisely measured by, first, decreasing the sweep time to 5 milliseconds, at which point a trace like that shown in trace #4 will be visible on the screen. Such a trace illustrates that the shutter started to close at the end of 5 milliseconds. By decreasing the sweep time to $2^1/_2$ milliseconds, a trace like that in trace #5 might result, indicating that the shutter required $2^1/_2$ milliseconds to open.

Many shutter idiosyncrasies can be examined effortlessly because of the ease with which the sweep time may be changed and the controls adjusted on the Analyzer. For example, trace #6 shows the graph traced by a shutter having poor leaf lever control. The trace illustrates that the shutter leaves open fully, bounce

partially closed, and then reopen for the remainder of the exposure. Trace #7 illustrates the graph traced by a shutter having uneven opening and closing times. In this case, the shutter takes a great deal of time to open, but closes quickly.

Shutters with blade bounce can be detected merely by stopping the diaphragm down as far as it will go and choosing a sweep time 7 or 8 milliseconds longer than the total operating time of the shutter. Trace #8 shows the graph produced by a shutter having shutter blade bounce.

Efficiency comparisons and measurements are, of course, nicely made. Trace #9 shows the graphs traced by two shutters, each set at 1/500 second, but having widely different efficiency characteristics.

Because of the variety of triggering methods possible with the Analyzer, synchronization tests are made with a minimum of set up and interpretation time. A typical flash synchronization set-up is shown in Figure 4 and the trace provided by such a set-up with a shutter operating at high speed and *out* of "synch" is shown in Figure 3, trace #11. Without changing the sweep time, which may remain at .0200 second for most synchronization tests, traces #12A, 12B, and 12C show respectively, good synchronization for class M, class F and class X flash.

Contact dwell time, contact bounce and contact efficiency are clearly indicated and promptly analyzed

with this instrument. Traces #13 A, 13 B, and 13 C show the graphs obtained from three sets of "X" contacts in three different shutters operating at high speed. In each case the contact total dwell time is approximately one millisecond with the sweep time set at two milliseconds. Trace #13 A shows good contact, 13 B shows initial contact bounce and 13 C shows poor contact. A quality indicated in trace #13 B or better, is desirable when such contacts are to be used for extensive flash work.

Technical Specifications for Functions

Function A. Power fed into the data input by a photo-tube or other transducer will trigger the pulse and cause vertical deflection. Used primarily for shutter speed, vibration or pressure testing. With the sweep in the run condition, this function is used for measuring rotational speeds with input data as a modulator.

Function B. Closing contacts in series with the function output will trigger the sweep and cause vertical deflection. Used for testing contacts of all kinds, either transient or repetitive, and low voltage power sources.

Function C. Contacts in series with the function output trigger the sweep, but data input causes vertical deflection. This function is used for timing two separate, related actions such as contact closure and rotational movement or shutter operation.

Function D. Used almost exclusively with solenoids. Power from the Analyzer or from a battery case trips a solenoid and triggers the sweep while data input causes vertical deflection. A test button on the instrument itself can be used to trip a solenoid.

Function E. Used almost exclusively with battery case and solenoid, this function simulates the load of one flashbulb. Triggering and vertical deflection are similar to Function D, without the use of the test button.

Function F. This function is the same as function E, except that the simulated load is equal to two flashbulbs.

HORIZONTAL SWEEP TIME: .0005 to 9.99 seconds, plus or minus 1% with calibration.

POWER REQUIREMENTS: 70 watts, 105 to 125 volts, 60 cycle AC.

LAMP OUTPUT: Low—3 volts AC; High—6 volts AC.

TRIGGER: Sensitivity—$1/2$ volt. Blocking time for given data voltage: 2.5 seconds at 10 volts; 6.0 seconds at $1/2$ volt.

VERTICAL AMPLIFIER: Frequency response—DC to 100 KC. Maximum input voltage—100 V AC or DC. Input resistance—4 megohms (data rise control full clockwise). Input resistance—0 ohms (data rise control full counter-clockwise). Maximum sensitivity—10 volts per inch.

TUBE COMPLIMENT: 1 5BPl Cathode Ray Tube, 1 6SN7 Vertical Amplifier, 2 6SJ7 Horizontal Amplifier, 2 5Y3 Rectifiers, 1 12AX7 Trigger Amplifier, Horizontal Amplifier, 1 6J5 Trigger Blocking Tube, 1 2050 Thyratron Saw-tooth Oscillator, 1 930 Photo Tube.

Circuit Condition at function output terminals for the various positions of the function selector switch:

Position A.   Open circuit.
Position B.   10 volts DC at function output, internal.
Position C.   Same as B.
Position D.   10 volts to 500 ohm load, 1.6 amps to 1 ohm load, (supplied when test button is pressed.)
Position E.   Input resistance duplicates load of 1 flashbulb.
Position F.   Input resistance duplicates load of 2 flashbulbs.

Summary

A cathode ray tube oscillograph with controlled and easily calibrated sweep times provides a base for measurement of many transient or recurring phenomena in photographic equipment. The applications, briefly covered here, are limited only to the extent of the operator's ingenuity. Additional applications using a variety of transducers to provide voltage changes to the data input are easily developed. After choosing the proper transducer, it is only necessary to set the sweep time at the period of revolution or recurrence to examine the activity. By reversing the procedure, the time per revolution—or any period—may be accurately measured.

The Analyzer's total-sweep-time principle can eliminate a major portion of the set-up time required when tests are made with standard oscilloscopes. The simple calibration procedure permits inexperienced personnel to gain the advantage of oscilloscopic accuracy and ease of interpretation.

Fig. 4. Typical set-up of the Analyzer for flash synchronization testing.

References

1.   "Handbook of Photography," Henney and Dudley, Chapter 5.
2.   "The Versatile Gardner Synchrotimer," National Camera Repair School, 1956.

BOOKS FOR TECHNICAL READERS

MICRORECORDING, Industrial and Library Applications, Chester M. Lewis and William H. Offenhauser, Jr. Interscience Publishers, Inc., 250 Fifth Avenue, New York 1, N. Y. 1956. 468 pages, illustrated, $8.50.

The authors, in the Preface to this volume, expressed the modest hope that it "will fill the needs of non-technical and technical people alike with a common interest in the use of microrecording." They refer to the fragmentary state of the current literature on microrecording; "short papers dispersed in a wide variety of often unrelated publications." It has been their purpose to organize this miscellany into a comprehensive, organized, and logical survey of microrecording as it exists today.

Perhaps the most remarkable features of this book are the completeness with which it covers the subject, the competence with which both the library and technical aspects (user and producer) have been treated, the timeliness of some of the material, the extensive references to American Standards (including some preliminary proposals which are so tenuous in nature as to be little more than a gleam in the eye of a standards draft writer), and the extensive bibliographical lists which follow each of the sections into which the work is divided.

The authors are about as complementary a pair as could be imagined for a work of this sort. Chester M. Lewis, presently Chief Librarian on a large newspaper in New York City, was formerly President of the Special Libraries Association, a group concerned with the special problems of libraries in industry, in business, and in the professions apart from education. William H. Offenhauser, Jr., the energetic author of the reference work "16-mm Motion Pictures", is a photographic consultant of New Canaan, Connecticut. He is well known in motion picture, television, and general photographic engineering and technical circles and has had wide experience in photography, including the management of a commercial 16mm film processing laboratory in New York City.

Both of the authors are known to be energetic and diligent fellows. The book shows the unsparing effort with which they have sifted through the literature and pursued obscure facts to bring together in harmonious relationship a tremendous amount of data. The organization of these data, the evaluation and interpretation, the sorting out of significant facts and trends from a welter of information; have produced a volume of great practical value as a reference work and guide to the uninitiated.

Microrecording starts with a sensible discussion of the aims of a record retention program. The reader who has a problem involving the keeping and subsequent location of records will, perhaps, find here a way to obtain for the first time a clear picture of the nature of his problem and its dimensions. Such an analysis of the problem is a necessary prerequisite to selection of the best microrecording solution.

The succeeding sections of the book deal with (1) selection of a microrecording program, with consideration of capabilities of the several methods and their cost, (2) the technical aspects of the microrecording process, (3) cameras and their operation, (4) the microrecord itself and its technical problems, (5) duplicating, processing, and enlarging microrecords, (6) readers and projectors, (7) storage and preservation of microrecords.

One section deals with business and legal requirements of a record retention program, a subject often overlooked in discussions of microrecording. This considers not only the legal uses of micro records as evidence and as instruments of commerce but also with the question of copyrights and the liabilities encountered in the making of microrecords.

An especially provocative section discusses the frequently perplexing subject of information classification and retrieval. Problems in this field often sharpen the need for a microrecording system but micro-recording brings problems of its own as well as advantageous solutions for the already existing problems.

An extensive appendix and index of some 115 pages enhances the value of the volume as a reference work. Here are presented exact quotations of laws and recommendations of governmental departments and industries concerning the nature and use of micro-documentation. A number of American Standards have been reproduced here, photographically, which would cost about half as much as the book if purchased from the American Standards Association.

The book, despite its association with library usage, has been produced by singularly unattractive typographic treatment. It is well printed and substantially bound but the very light bodied text stands in jarring contrast to the black Bodoni headings and to worsen the effect, still a third face, a bold, old style letter, is used for the subheadings. A reference book does not need to be pretty but it ought to have the dignity and good taste of compatible typography. The excellent fund of information contained in this book deserves better styling. P.A.

CLOSE RANGE PHOTOGRAPHY, C. H. Adams, Focal Press Ltd., London. 1956. 190 pages, $4^{7}/_{8} \times 7^{1}/_{4}$ inches, illustrated. Available from AMPHOTO, 33 West 60th Street, New York, New York. $4.50.

A practical how-to-do-it book by a man who actually did it with ordinary camera equipment. The photographer who is called upon to make extreme close-up photographs too seldom to justify the expense of special camera and lighting facilities will find here the directions he needs for doing the work with almost any kind of normal camera equipment.

The author, a Civil and Mechanical Engineer, has been taking photographs for more than fifty years. The directions given are written in a highly practical manner, are illustrated by the publisher with many diagrams and sketches of exceptional clarity. The results achieved by the author and by others, using various methods and types of camera equipment mentioned in the book are illustrated with 37 halftone pictures.

No necessary topic has been overlooked or omitted. It is all here, including studio and darkroom layout and equipment, electrical equipment and lighting techniques, exposure determination, the use of color materials, backgrounds, darkroom manipulation and processing hints. M.E.A.

PHOTOJOURNALISM, Arthur Rothstein. American Photographic Book Publishing Co., 33 West 60th Street, New York, N.Y. 1956. 200 pages, $7^{1}/_{4} \times 10$ inches, profusely illustrated. $5.95.

This is an important book. It is a picture book with words. Both the pictures and the words are important. Each complements and illuminates the other.

This is a book of instruction and at the same time a book to enjoy. It is a man's description of his job and the man emerges from the description. The subtitle defines PHOTOJOURNAL-ISM in five words: *pictures for magazines and newspapers.* The pictures, taken from 1853 to 1956, show how a new form of

20

communication and public information started and grew in importance. How the picture and the word, join together the work of the author and the cameraman in today's expressive journalism, is the theme of the book and the book itself exemplifies the theme. What the art director and the editor, and all the other technical workers have to do, and how they do it, are made clear by words and, most graphically, by pictures.

This is an important book to own. The things one can learn from it are endless. For a modest price, the publishers have produced a picture book with nearly faultless half-tone reproductions of photographs. The quality of the printing, by American Book-Stratford Press, is equal to that of many "camera art" albums. The typography, the page styling and make-up are a delight to see. The pictures, and the words written about the pictures fulfill ten times over the promise on the jacket: "How to tell a story with photography."

This is a book for everyone who owns a camera, for everyone who takes pictures for pleasure or for profit. It is a book for the person of understanding and thoughtfulness who never takes a picture but only looks at them in newspapers and magazines. It does more than teach one how to take photographs, how to create pictures, how to tell a story with pictures; this book and its pictures, selected with understanding, insight, and inspiration, teach us how to look at the world we live in.

The author, Arthur Rothstein, 16 years with Look magazine, is widely known to photojournalists. A Columbia University graduate in physics and chemistry, he has seen his pictures selected for the permanent collections of the Museum of Modern Art, George Eastman House, the Library of Congress. He has received many awards and citations here and abroad for the excellence of his pictures. His first book may well stand as his greatest accomplishment to date.   H.O.P.

FRITZ HENLE'S GUIDE TO ROLLEI PHOTOGRAPHY, Edited by George B. Wright. The Studio Publications, Inc., and AMPHOTO, New York, 1956. 208 pages, $7^1/_4 \times 10$ inches with many illustrations, some in color, $6.75.

An opening chapter "Getting Acquainted with your Rollei" and a closing chapter "Rollei Accessories and Data" fail to detract from the charm and excellence of this account. Beautifully printed and lavishly illustrated, the book should instruct and inspire anyone who cares to improve either the technical or the artistic quality of his pictures. While the unique advantages of the twin-lens reflex camera are pointed out, the photographer who owns any other sort of camera equipment has much to learn from the instruction and from the examples of this master photographer.   H.O.P.

NATIONAL STANDARDS IN A MODERN ECONOMY, Dickson Reck, Editor. Harper & Brothers, Publishers, New York, 1956. 372 pages. $5.00.

Written by 33 authorities concerned with various aspects of standardization, this book has been edited by the late Dickson Reck, former Professor of Business Administration at the University of California, Berkeley. The volume was conceived as a tribute to and is dedicated to the memory of Paul Gough Agnew, who was Secretary of the American Standards Association during its formative years from 1919 to 1947. To many workers on national standards committees in the U.S.A. during that period, "P.G." Agnew was both an inspiration and a guide.

In the opening chapter, Herbert Hoover pays tribute to the national standardization movement, promoted by the American Standards Association, and to the vast number of American Standards which "have been the result of spontaneous, voluntary, yet organized cooperation within highly individualized industry." In the closing chapter, Roger E. Gay, U. S. Department of Defense, speaks of standards as tools of industrial management. In the intermediate 31 chapters various aspects of standardization in a modern economy are discussed. Separate chapters deal with international standards, governmental standards, quality control standards, the use of standards in telecommunication, in agriculture, in pharmacy, medicine, surgery, and textiles. Standards in the photographic industry are covered by Paul Arnold, Chairman of the Photographic Standards Board of the A. S. A.

Part III presents eight chapters dealing with implications of the use of national standards to industrial management. Walter Reuther describes the use of standards by organized labor. Other chapters are concerned with consumer standards, with the relationship of standards programs to the Sherman Act, and the effect of standards on international relations and the national economy, including conservation of national resources.

This is a comprehensive and authoritative book which shows how far national standardization has come in the United States from its beginnings within the engineering fraternity to its present cooperative endeavour in which industry and commerce, government and the consumer, all participate.

M.E.A.

PRINCIPLES OF COLOR TELEVISION, The Hazeltine Laboratory Staff, Knox McElwain and Charles E. Dean, Editors. John Wiley & Sons, Inc., Publishers, New York, 1956. 595 pages, $13.00.

Unlike color printing and natural color photography, which evolved during many years of continuous development, color television became the subject of widespread attention, public interest and demand while it was still a laboratory curiosity. Due to the limitations placed on color television broadcasting in favor of the already existing black-and-white television industry, color television has become the most complicated device which has ever been conceived and reduced to practice for common use by the general public.

In the Foreword, Arthur V. Loughren, former Vice-President in charge of Research for the Hazeltine Electronics Corporation, explains the problem. "The necessity for having to describe each element of the picture with three separate pieces of information instead of only one would seem to indicate that information should be transmitted at a rate of 750,000 elements per picture period for color rather than the 250,000 elements required for monochrome." How this seeming impossibility, considering the 4-megacycle effective bandwidth which is available in the present 6-megacycle channels, is circumvented is one of the carefully explained and illustrated accomplishments of the present volume.

The first 135 pages of the book deal with fundamental aspects of light and photometry, color perception, colorimetry, the physiological and optical aspects of the human eye, and the characteristics of a television system which relate to physiological and psychological requirements.

The remainder of the book is devoted to the electronics of the color TV system in large part. Most of the technology is explained in a lucid manner, making use of simple mathematics, simplifying the explanation with sacrificing accuracy. In-

volved matters such as the "incoding" at the studio end and "decoding" at the receiver end are covered but more than a casual reading will be required to absorb such details.

An elementary knowledge of the functions of vacuum tubes may be required in order to assimilate the information contained in the book but a thorough education in electronics is by no means necessary. The Hazeltine Laboratory staff members who prepared the separate sections assumed a group of readers who would be familiar with the engineering theory and techniques of monochromatic television. Altogether it is undoubtedly the most complete and easy to read treatise on color television that has yet appeared in print. Lou Stantz

INTERNATIONAL PHOTOGRAPHY YEARBOOK 1957, Edited by Normal Hall and Basil Burton. St. Martin's Press, Inc., New York, N. Y. 1956. 192 pages, $7\frac{1}{2} \times 10\frac{1}{2}$ inches. $5.95.

This is the best of the current crop of Annual picture books to come to our attention. The editors examined 20,000 prints and selected 182 for reproduction. The editors, who have been doing this sort of thing for ten years, think this year's pictures are better as a group than any shown before. The discriminating viewer very likely will agree.

The pictures come mainly from the world's best professionals but there are a number from amateurs as well. A special feature is an appraisal of the work of five "star photographers": Robert Doisneau, Alfred Eisenstaedt, Bert Hardy, Toni Schneiders, and Rolf Winquist.

The printing by the Sidney Press Ltd., London, is first rate. Throw away the dust jacket with its provocative "news stand" picture, and this is a book you will be proud to have on your living room table. P.A.

LETTER OF CORRECTION

Sirs:
"I regret to say that there is one major error in the November issue of Photographic Science and Technique which concerns my paper on the 'Safe Handling of Photographic Processing Chemicals.'

"On the right hand column of page 160 the heading 'Dermatitis' has been omitted before the commencement of the section on dermatitis. The heading 'Dermatitis' should have come just before the second paragraph from the bottom beginning, 'The word dermatitis' etc."

David W. Fassett, M. D.
Eastman Kodak Company
Rochester 4, New York

SILVER HALIDE PRECIPITATION.   II.

C. R. Berry and S. J. Marino*

ABSTRACT

The precipitation which occurs when silver ions are added to a mixture of bromide and iodide ions was described in an earlier paper as a two-step process in which an initial precipitate of silver iodide and then silver bromide are formed. During the second step, the unlike crystals which are present tend to dissolve and recrystallize as mixed crystals. Further details of these processes are given here. Electron-microscope photographs indicate that the sites for nucleation and growth of mixed-crystal phases are at the surfaces of crystals already present. Reactive sites, particularly at the corners and centers of faces of the initial crystals, seem to be effective locations for new growth. Iodide-rich phases, which have not redistributed and are present in too small quantities to be observed in the ordinary x-ray patterns, are shown to be associated primarily with the larger grains. Increasing the rate of precipitation produces a more uniform iodide distribution. During fast precipitations, much silver bromide is present in the initial stages of silver addition. This non-equilibrium silver bromide disappears with a time constant of about two seconds. The composition of the major phase in the final precipitate is greatly affected by the rate of silver bromide formation in the second step of the precipitation, but is not affected by a drastic change in the character of the initial precipitate.

IN AN EARLIER PAPER,[1] a description was given of the precipitation which occurs when silver ions are added to a mixture of halide ions. It was found that first additions of silver caused the least soluble component of the mixture to precipitate first: pure silver iodide in the silver bromoiodide system and in the chlorobromide system, a phase having a composition in the range of 98 to 99 mole percent bromide. During the later stages of precipitation, a large amount of solution and redistribution of the initial precipitate occurred. The rate of reaction of the initial precipitate with crystals precipitating later in the run was increased by raising the temperature or solvent

concentration or by precipitating in the presence of gelatin.

Some aspects of this precipitation scheme are considered in more detail here than in the earlier work. One aim is to specify the sites of nucleation and growth of the new phases formed by reaction of the unlike phases which are present. Another problem is to find the location of a small amount of silver iodide known to be present, but for which there is no evidence in the ordinary x-ray diffraction patterns. A third purpose is to investigate the effect of the rate of addition of silver to the halides.

As in the work reported previously, the analysis of the solid phases was made from x-ray diffraction patterns. In addition, some electron-microscope photographs were obtained from some of the grains.

Nucleation Sites for Crystal Growth

It is of interest to determine the sites of reaction for the formation of the new phases which are produced when unlike phases are present during a precipitation. Clearly, the nucleation of a new phase must occur in regions where there is an abnormally high supersaturation of silver and halide ions. This consideration implies that the new phases would be likely to begin their growth near the surfaces of crystals which are dissolving.

An interesting demonstration of this type of behavior was accomplished by putting precipitates of pure silver iodide and pure silver bromide in separate vessels and immersing both of them in a third vessel containing a potassium bromide solution (150 grams/liter) which acted as a solvent contact between the pure components. After 25 days at 50 C, some orange crystals had formed on the surface of the silver iodide. The orange crystals had the silver bromide type of crystal structure and contained 42 mole percent of silver iodide. At the same time, the pure silver bromide crystals were converted to a mixture of two phases containing 4.2 and 10.2 mole percent silver iodide. No crystals were found elsewhere in the vessel. The inference from these results is that nucleation and growth of new phases is likely to occur in the vicinity of either the silver iodide or the silver bromide.

A similar experiment was carried out with silver chloride in one vessel and silver bromide in another, both immersed in a vessel containing a potassium chloride solution (10 grams/liter). After 25 days at 50 C, a single phase containing 32 mole percent bromide was found in the vessel where there had been silver chloride and a single phase containing 43 mole percent chloride where there had been silver bromide.

To gain further information on the nature of such reactions, electron micrographs were obtained[2] for grains under a variety of conditions. The first set of experiments was carried out to observe the reaction of pure silver bromide crystals with iodide ions in solution. Figure 1 shows the result of adding 20 mole percent potassium iodide (based on silver bromide) to a potassium bromide solution (9.6 grams/liter) at 70 C containing pure silver bromide grains which had been precipitated in gelatin and ripened for 30 minutes. The reaction with potassium iodide was stopped after 2 minutes by diluting the specimen with cold water. The electron micrographs show clearly that certain silver bromide grains were largely broken up while others were quite unchanged. Corresponding x-ray diffraction patterns identified the reaction product as silver iodide rather than as mixed crystals of cubic silver bromoiodide which we know to be present at a later time. Similar experiments with smaller amounts of potassium iodide differed from those shown in Figure 1 only in that a smaller fraction of the silver bromide grains was attacked by the iodide. The reverse situation of reaction of silver iodide crystals with bromide ions in solution is not particularly interesting, since the only change which occurs is grain growth without an appreciable incorporation of bromide ions in the iodide lattice.

Electron micrographs from the grains of various compositions of mixed silver halide precipitates were obtained at various times during precipitation. Particular attention was given to specimens obtained at times just
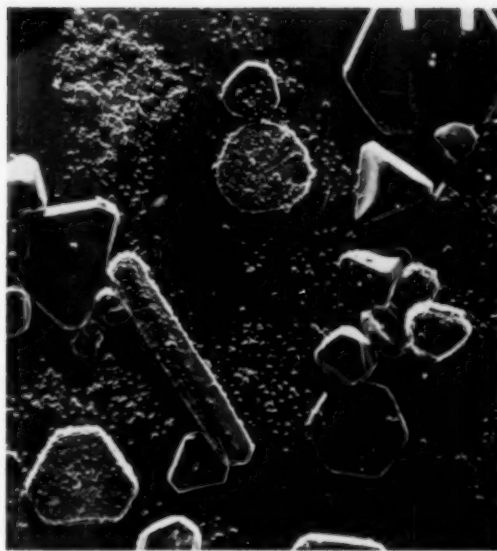

Fig. 1. Reaction of 20 mole percent potassium iodide with pure silver bromide grains for 2 minutes at 70 C. One micron is represented by the separation of the white marks on the upper edge at the right.

before and after the least soluble component would be completely precipitated. It was hoped that in this way the rather remarkable changes which have been inferred from the crystallographic observations would be demonstrated in the grain photographs. Unfortunately, this could not be done in most cases because only slight changes were seen in the electron micrographs and no definite shapes or sizes of crystals could be attributed to a specific crystallographic phase as determined from the x-ray diffraction patterns of the same specimens. However, there was a particular set of conditions for which the meaning of the electron micrographs was quite clear and could be well correlated with the crystal structure data.

This was for a precipitate made in the usual way but having a final composition of equal parts of chloride and bromide (50 Cl—50 Br). A typical precipitate of this composition was made by adding slowly 10.00 grams of silver nitrate dissolved in 50 ml of water to a solution containing 3.08 grams of potassium chloride, 3.50 grams of potassium bromide, 3.3 grams of gelatin, and 100 ml of water. Figure 2 shows the precipitate after 44 percent of the silver ions had been run into the mixture of bromide and chloride ions and gelatin at 70 C and after 15 minutes of ripening to remove the smaller crystals before continuing the addition of silver. The x-ray diffraction photographs show that, at this stage, the crystals consist of a single phase of 97.6 mole percent bromide. Figures 3 and 4 represent the precipitate at the point where 60 percent of the total silver ions had been added. The changes occurring on running in the small amount of additional silver are quite spectacular. In many instances, projections with definite orientation have grown on the corners or face-centers of the grains in the initial precipitate. The corresponding x-ray diffraction patterns show that, in addition to the phase originally
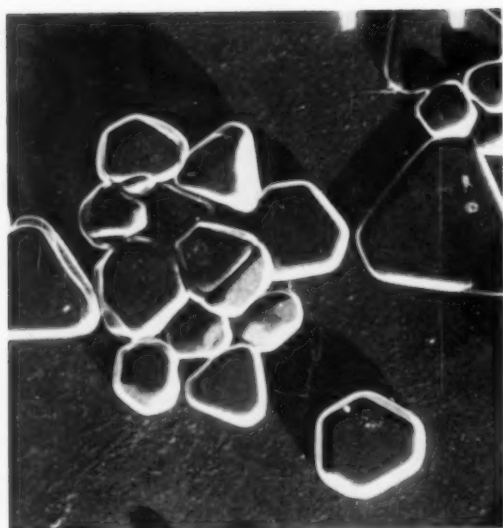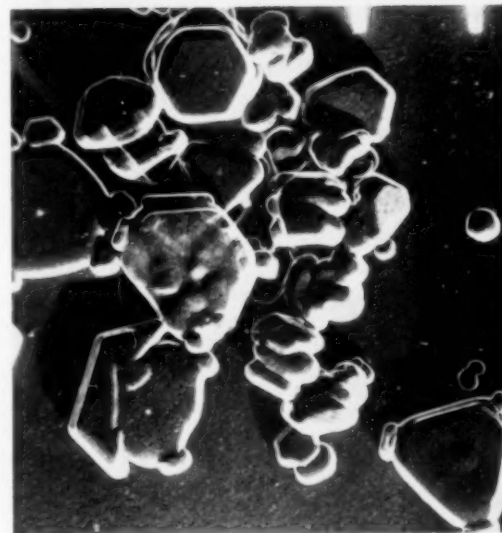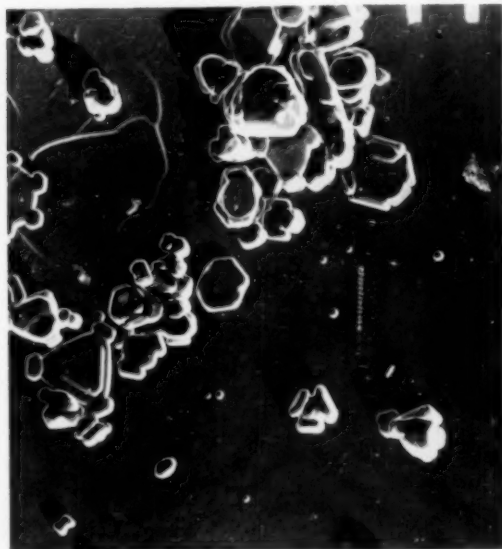
Fig. 2. At this stage during the precipitation of a 50 chloride-50 bromide, 44 percent of the silver ions had been added. A single phase of composition 97.6 mole percent bromide is observed. One micron is represented by the separation of the white marks on the upper edge at the right.

present, about one-fourth of the material is in the form of a mixed crystal of composition 39 chloride—61 bromide. Thus, the projections observed in the electron micrographs are of this new composition. The small spherical grains in Figure 3 are probably of unreacted silver chloride and are not sufficiently numerous to be detected in the x-ray diffraction pattern. There is little doubt that the nucleation of the new phase has occurred near reactive sites at the surface of the grains of the intial precipitate. Apparently, the more reactive sites are often corners or centers of the faces of the grains.

From observation of electron micrographs like Figures 3 and 4, it has not been possible to see to what extent there may be nucleation of new phases at the surfaces of the more soluble grains. Although Figure 1 demonstrates that such a reaction takes place under certain conditions, it may be that this reaction is only of minor importance in the precipitation method which we are considering here.

It must be noted that the composition represented by the crystals shown in Figures 3 and 4 is somewhat unusual in the regularity of growth and the large size of the appendages which occur at the surface of the initial precipitate. This is probably influenced by the fact that the reaction product which has the composition, 39 chloride—61 bromide, is close to the composition of one of the major phases found at the end of the run. The persistence of this composition throughout the run allows a rather long time for it to grow. In other cases (especially in the bromoiodides), where a number of different compositions are observed at different times during the run, there may not be time for any of the intermediate phases to grow in the form of large, regular appendages. Nevertheless, it may well be that nucleation and growth of new phases generally begins near the surface of the least soluble crystals of a mixture.

In view of this, it may seem surprising that Baldsiefen, Sease, and Renwick[3] found that the size of the silver iodide crystals produced during the early part of a precipitation has no effect on the photographic properties of the resulting emulsion. We have investigated this conclusion further and have found little effect of different sizes of initial grains of silver iodide on the grain size and on the composition of the major phase at the end of a precipitation. These results make it clear that, although the nucleation sites for growth of new phases may often be at the surface of the least soluble crystals of a mixture, there is not a one-to-one correspondence of each crystal

Figs. 3 and 4. At this stage during the precipitation of a 50 chloride-50 bromide, 60 percent of the silver ions had been added. There are two phases: 97.6 mole percent bromide and 61 mole percent bromide. One micron is represented by the separation of the white marks on the upper edge at the right.

in the final precipitate and a crystal in the initial precipitate. A particular crystal in the initial precipitate may be the site of nucleation of several new crystals or, on the other hand, it may dissolve without nucleating any new crystal.

Hidden Iodide-Rich Phases

Another aspect of this precipitation which was discussed briefly in the earlier paper[1] is the problem of the missing iodide. There is generally observed in bromoiodides of low iodide content precipitated in gelatin at 70 C only one crystallographic phase which contains about one-half as much iodide in solid solution as is known to be present. The remainder of the iodide was presumed to exist in the form of finely divided silver iodide or high-iodide content material. Since centrifuged fractions of the grains failed to show any phase of high-iodide content, it was assumed that the iodide was associated with the grains containing the major phase.

Further experiments have now been carried out which give some indication of the amount of the missing iodide in grains of different size. Grains having an average composition of 6 mole percent iodide were produced by adding 10.0 grams of silver nitrate in 50 ml of water to a solution of 3.3 grams of gelatin, 7.99 grams of potassium bromide, and 0.586 gram of potassium iodide in 100 ml of water at 70 C. At the end of the 30-minute precipitation, the reactions were stopped by adding the precipitate and solution to 1500 ml of water at 10 C. The coarse fraction was obtained by collecting the grains which settled in 30 minutes, and the fine fraction was obtained by collecting and centrifuging a portion of those grains still suspended after a total of 2 hours. The diffraction patterns of each grain-size fraction were examined and, in addition, patterns were obtained after prolonged ripening of the grains at 50 C in a solution of 200 grams of potassium bromide per liter of water. The prolonged ripening causes the iodide in the grains to distribute uniformly and gives a composition which is the same as would be obtained by ordinary analytical methods after dissolving the grains.

The analysis of the x-ray patterns, averaged for four separate precipitations, gave the following results:

Coarse Fraction	*Fine Fraction*
2.7% Iodide	2.1% Iodide
Coarse Fraction Ripened	*Fine Fraction Ripened*
6.9% Iodide	3.1% Iodide

These values show that the amount of missing iodide is about four parts per 100 parts of bromoiodide in the coarse grains and one part per 100 parts of bromoiodide in the fine grains. The exact composition of this missing iodide cannot be specified since its diffraction pattern has not been observed. However, it appears reasonable that it is primarily in the form of pure silver iodide and/or 45 mole percent iodide in silver bromide-iodide, both of which have been shown to exist in considerable quantities at early stages of a run. The indication from Figures 3 and 4 is that the initial precipitate (iodide-rich material) is covered by other material.

In the silver chlorobromide system, a comparable situation of missing bromide occurs at low bromide compositions and presumably is explained in a manner similar to that for the bromoiodide.
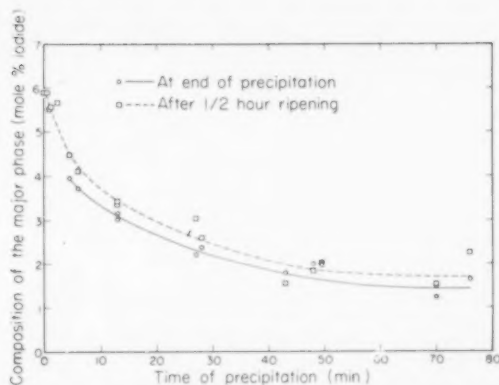

Fig. 5. The effect of the time of precipitation on the composition of the prominent crystallographic phase which is observed. The total iodide content is always 6 mole percent.

Effect of the Rate of Silver Addition

A variable which was not previously investigated is the rate of addition of the silver nitrate solution to the mixture of halide salts and gelatin. In the present experiments, the times of precipitation vary from a few seconds to 76 minutes, whereas the earlier studies were made of precipitates produced in about 30 minutes. The concentrations of bromide and iodide ions were chosen to give an average composition of 6 mole percent iodide in the solid and an excess of 20% potassium bromide in solution at the end of the run. Specimens were obtained immediately following a run and also after ripening for 30 minutes at the precipitation temperature of 70 C. The compositions which were observed are shown in Figure 5. The results for longer times of precipitation correspond with those reported earlier and have the characteristic that about half (or less) of the iodide ions are incorporated in solid solution with silver bromide. The shorter times of precipitation result in more nearly uniform distribution of iodide in the silver bromide, especially in the ripened grains. No points are plotted at times shorter than 4 minutes for the unripened precipitates because of the wide distribution of compositions which existed in these cases. A few precipitates which were made with violent stirring gave results which were not appreciably different from those given in Figure 5. However, in some other methods of precipitation, the stirring rate is of importance.

The more uniform and more complete distribution of silver iodide in the silver bromide for the shorter times of precipitation must mean that the decreased time available for reaction between the silver iodide precipitated early in the run and the silver bromide precipitated late in the run is more than counterbalanced by having grains of greater reactivity, owing to finer grain size. It is a necessary condition for achieving a relatively uniform iodide distribution that high reactivity of the grains be maintained near the end of the run because the equilibrium composition toward which the grains are approaching changes continuously during this kind of a precipitation. Only after all of the silver has been added do the

Table I

EFFECT OF THE RATE OF PRECIPITATION ON PRECIPITATES CONTAINING PRERIPENED SILVER IODIDE

Time of Precipitation Minutes	Composition of Precipitate with Preripened Silver Iodide		Composition of Ordinary Precipitate (from Fig. 5)		Change in Composition Produced by Preripening the Silver Iodide	
	At End of Run	After Ripening	At End of Run	After Ripening	At End of Run	After Ripening
2.67		4.62		4.99		−0.37
2.87		5.00		4.90		+0.10
23.8	2.20	2.70	2.45	2.74	−0.25	−0.04
80.9	1.42	1.50	1.41	1.68	+0.01	−0.18

grains approach the equilibrium composition of 6 mole percent iodide.

Another interesting aspect of the very rapid precipitations is that it is not accurate to describe them in terms of a two-step process in which the silver iodide precipitates alone during the first step. In fact, it has been observed that a considerable amount of silver bromide is present at the start of the fast runs. The more common observation of a pure silver iodide phase (during the early stages of a slow precipitation) represents the equilibrium situation. In the faster runs, there is not time to establish this equilibrium. As an example, when a precipitate was sampled after 6 seconds of a run whose total time was 2.6 minutes, at which time 4% of the total silver was in the solid, approximately 5% of the solid was silver bromide in the usual sodium chloride type of structure. After such a precipitate had been permitted to equilibrate, there was no longer any evidence of silver bromide.

The presence of silver bromide in the early stages of a fast run emphasizes the probability that at the instant when a drop of silver nitrate solution enters the mixed halide solution, precipitation of both silver iodide and silver bromide occurs. We know, in fact, that where an excess of silver exists, as in the precipitation by addition of halides to silver, the precipitate is a homogeneous solid solution containing a fraction of bromide which is equal to the fraction of bromide present.

With certain assumptions, the description of the initial stages of a precipitation may be put on a quantitative basis. Two assumptions are made: First, at the instant of precipitation, the fraction (f_0) of silver bromide in the solid phase formed by each drop of silver nitrate is equal to the ratio of bromide to total halide ions in solution. Second, the decrease of concentration of bromide ions in the solid phase to silver iodide follows an exponential curve, $\exp(-t/T)$, with time constant T. Then, when a specimen is taken at a time, t_1, after the start of a precipitation and when the reaction in this sample is completely stopped after an additional time, t_2 (by diluting the specimen in ice water), we can show that the fraction of bromide remaining is

$$f = f_0(T/t_1) \exp[-(t_1+t_2)/T][\exp(t_1/T)-1].$$

In typical experiments which were carried out to determine T, values were:

$$t_1 = 5 \text{ sec. and } t_1 = 6$$
$$t_2 = 3 \text{ sec.} \quad t_2 = 5$$
$$f = 0.05 \quad f = 0.03$$
$$f_0 = 0.95 \quad f_0 = 0.95.$$

In both cases, the value of T is about 2 seconds.

By using the relationship just given, it is possible to compute the fraction of bromide present for conditions which would be very difficult to measure without substantial changes in the measuring techniques. For example, in a 30-second precipitation, when enough silver has been added to equal the amount of iodide in solution, the fraction of silver bromide present is 0.66. For a 30-minute run, the value would be 0.01. Thus, in this precipitation scheme, the approximation that silver iodide precipitates first is not at all valid for short runs but is essentially correct for long runs.

As stated earlier in this paper, the nature of the silver iodide, whether large or fine grains, has little effect on the character of the final precipitate. This implies that the second step, during which silver bromide precipitates, is primarily responsible for differences which arise, such as when precipitates are formed in different times. This may be investigated by comparing the compositions of precipitates formed in different times in the ordinary way (the results of which were given in Figure 5) with precipitates formed in various times but with preripened grains of silver iodide. Preripening of the silver iodide was accomplished by stopping the run and keeping the precipitate at 70 C for 60 minutes after only enough silver nitrate had been added to the mixture of halides and gelatin to precipitate the iodide (6 percent). This ripening procedure produced large silver iodide grains having an average diameter of about 0.5 μ. The runs were continued with various rates of addition of the silver nitrate. The results are given in Table I. The times of precipitation are given in the table as if the rate of silver nitrate addition were constant throughout the entire precipitation. It is clearly demonstrated that the composition of the major phase in the resulting precipitate was determined by the rate of silver bromide formation during the second step of the precipitation process, and it was not affected by the drastic change in crystal size of the initial silver iodide precipitate. This must mean that the reaction between the silver iodide and silver bromide phases in these precipitates is not limited by the rate at which the silver iodide crystals redissolve.

References

1. C. R. Berry and S. J. Marino, Phot. Sci. and Tech., Ser. 2, Vol. 2, p. 149 (1955).

2. The micrographs were prepared by C. F. Oster, Jr., who used a revision of the method of metal shadowing and carbon replication which was described by D. E. Bradley, Brit. J. Appl. Physics, Vol. 5, p. 96 (1954).

3. W. D. Baldsiefen, V. B. Sease, and F. F. Renwick, Phot. J., Vol. 66, p. 163 (1926).

PSA TECHNICAL PAPER AWARD FOR 1956

J. I. Crabtree*

THE PSA TECHNICAL PAPER AWARD for 1956, given for the best technical article appearing in any official publication of the Society during each calendar year, was bestowed upon co-authors Val R. Pieronek, Warren L. Syverud, and William F. Voglesong for the paper "Printing the Color Negative," published in the November 1956 issue of Photographic Science and Technique. Messrs. Pieronek, Syverud, and Voglesong are members of the Color Technology Division of the Eastman Kodak Company. Citations are appended.

The inter-division award committee, working under the sponsorship of the Photo-Techniques Division, awarded an Honorable Mention to D. B. Glass and J. A. Cogan, Eastman Kodak Company, for their paper entitled "Fundamentals of Reversal Color Processing," published in the November 1956 issue of Photographic Science and Technique, and to M. R. Goff, Eastman Kodak Company, for his paper entitled "A Psycho-Physical Study of Stereo Slide Alignment," published in the May 1956 issue of Photographic Science and Technique.

The awards committee consisted of H. H. Duerr and C. B. Neblette, representing the Photo-Techniques Division; L. B. Dunnigan, representing the Stereo Division, W. K. Raxworthy, representing the Color Division, A. C. Peed representing the Motion Picture Division and Chairman John I. Crabtree, of the Photo-Techniques Division.

Formerly known as the *Journal Award*, this formal recognition of the outstanding technical paper published in each calendar year was instituted in 1949. Following are the respective authors honored in years past:

1949—J. I. Crabtree, FPSA: "Rapid Processing of Films and Papers" PSA Journal Vol. 15, pp. 130–136, Feb. 1949.

1950—F. B. Noel, FPSA and P. B. Davis: "New Low-Voltage Low-Power Flashtube of High Efficiency," PSA Journal Vol. 16B (PS&T): pp. 11–16, Jan. 1950.

1951—L. A. Jones, Hon. FPSA: "Psychophysical Evaluation of Quality of Photographic Reproductions," PSA Journal Vol. 17, pp. 751–764, Dec. 1951.

1952—R. W. Henn, FPSA: "Properties of Developing Agents II. Paraminophenols" PSA Journal Vol. 18B (PS&T), pp. 90–95, Oct. 1952.

1953—F. V. Chu, R. W. Nottorf, and W. H. Vinton: "Swelling Characteristics of Synthetic Polymer Emulsions Under Processing Conditions" PSA Journal Vol. 19B (PS&T) pp. 43–47, May 1953.

1954—Lester Horwitz: "Mechanisms of Color Sensitization" PSA Journal Vol. 1 (PS&T) pp. 43–51, May 1954.

---
* Chairman, Technical Paper Awards Committee, PSA Photo-Techniques Division.

1955—T. Howard James: "Dependence of the Rate of Development of Surface Latent Image on the Temperature of the Developer" PSA Journal Vol. 2 (PS&T), pp. 81–90, May 1955.

The regulations governing the Technical Paper Awards Committee appeared on page 9 of the Administrative Practices for the old Technical Division of the Photographic Society of America, approved by the PSA Board of Directors October 6, 1954, and are as follows:

"Sec. 2: (b) 1. The TECHNICAL PAPER AWARDS COMMITTEE shall consist of a Chairman, two members appointed by the Technical Awards Committee Chairman, subject to approval by the TD Chairman and by the TD Executive Committee, and one representative from each of the following Divisions other than TD who wish to participate: Color, Motion Picture, Nature and Stereo.

2. *Duties:* Its duties shall be to recommend to the TD Executive Committee the author or authors of the best technical paper published in the PSA Journal, Photographic Science and Technique or any other official PSA publication, to receive the Division's Annual Technical Paper Award.
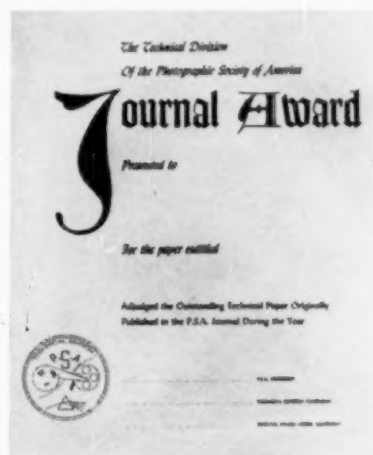
The PSA Technical Division diploma awarded annually to the author of the best technical paper to appear in an official publication of the Photographic Society of America.

3. *Award:* The PSA-TD Technical Paper Award shall be made on the basis of the following qualifications:

(a) The paper shall have been published originally in any official PSA publication, during the preceding year.

(b) The paper must deal with some scientific or technical aspect in the field of photography.

(c) In judging the merits of the paper, three qualities shall be considered, as follows:

1. Technical merit and importance of material	45%
2. Originality and breadth of interest	35%
3. Excellence of presentation of material	20%

A majority vote of the entire Committee shall be required for the election of the Award. Absent members may vote in writing. The report of the Committee shall be presented to the TD Executive Committee before March 1st of the succeeding year. At the annual meeting of the PSA a

Dr. Val R. Pieronek

Dr. Pieronek is a native of Michigan and received his A.B. degree in Chemistry from the University of Detroit in 1939. In 1942 he received his Ph.D. in Organic Chemistry from the University of Notre Dame. From 1943 to 1946 he served as a Lieutenant, J. G. in the U. S. Navy, stationed at the Photographic Science Laboratory in Anacostia, Md.

He has been employed in the Color Technology Division of the Eastman Kodak Company since 1946. During this time he has been engaged in development work on Dye Transfer, Eastman Color, and Kodacolor products and processes. At present he is the Section Supervisor of the Kodacolor Photofinisher Activities in the Color Technology Division.

Dr. Pieronek acquired an interest in photography at an early age through his experience in the Pieronek Studio in Detroit which is owned by his family.

Warren L. Syverud

Mr. Syverud is a native of South Dakota where he received his B.S. degree in Science and Journalism from the South Dakota State College in 1942.

He served as a Captain in the Army Air Corps from 1942 to 1945 and has been employed in the Color Technology Division of the Eastman Kodak Company since 1946. Much of his experience has been with professional color products, and he is now a photographic engineer in the Kodacolor Photofinisher Activities Section of Color Technology.

William F. Voglesong

Mr. Voglesong received his A.B. degree in Physics from Albion College, Michigan in 1944. His M.S. degree in Physics was granted by the University of Michigan in 1948.

For the next two years he was instructor at Michigan State Normal College and joined the Eastman Kodak Company in 1950. He worked for Hawk-Eye and the Naval Ordnance Division for two years before joining the Color Technology Division in 1952 where he was engaged in densitometric calibration work. He later joined the Kodacolor Photofinisher Activities Section where he is now working as a photographic engineer.

THE FLIGHT FROM THE MINIATURE

Photographers who have learned by experience that miniature cameras are not universally useful, and camera experts who never abandoned the use of professional-type cameras and normal size films, both will be interested in the English language edition of *Grossbild Magazine.*

The latest issue of this attractive new quarterly published and beautifully printed in West Germany includes an article on ultra wide-angle photography by use of a new 35mm wide-angle lens with 4 × 5 inch cameras to obtain a field over 100 degrees.

The excellent quality of the many full-page color and black-and-white illustrations makes *Grossbild Magazine* a collector's item of interest to everyone concerned with fine photography, camera techniques using professional cameras, and remarkably fine printing.

Grossbild is available at camera stores at 75 cents a copy or on subscription at $3.00 yearly. Subscriptions may also be obtained directly from Kling Photo Corporation, 257 Fourth Avenue, New York 10, N. Y., the U. S. distributors.

NEW THEORY EVOLVED
FOR ARC LIGHT

A new "particle" theory has been advanced by scientists at the Research Laboratories of National Carbon Company, according to their public relations organization. This attempts to explain where the bright light comes from in the carbon arc used in motion picture projection, and for photographic set illumination.

Dr. C. E. Larson, vice president in charge of research for National Carbon Company, a Division of Union Carbide and

Carbon Corporation, explains that the operation of the carbon arc can be understood by drawing a comparison with the use of a magnifying glass to focus radiation from the sun. A special furnace concentrates carbon-arc rays in a similar fashion. It produces a brightness intensity roughly equivalent to that of the sun's surface, in a region no larger than the head of a pin. At one time it was thought that the brilliant light comes from atomic processes in this crater cavity backed up by the glowing incandescent crater floor. But this theory has been radically modified by researchers at National Carbon's Parma, Ohio laboratories and what is now believed to happen is something far more complicated. Dr. Larson's explanation is as follows:

"Powerful electrical currents heat the crater region to temperatures of 10,000 to 12,000 degrees Fahrenheit. Part of the material at the floor of the crater vaporizes into tiny particles of the order of a millionth of an inch in diameter. These particles, probably in the form of white hot liquid droplets, stream out into the crater and on into the space between the carbon electrodes of the arc to form a long, luminous tail flame or 'comet tail.' Smaller particles, of atomic or molecular dimensions, also contribute something to the light, but are not the major source."

A detailed knowledge of this process is expected to lead to the development of brighter arcs and, combined with the results of crystal studies, to electrodes that will stand up to higher and higher currents and temperatures.

National Carbon's new laboratory at Parma, which is designed primarily for basic research in chemical and solid state physics, was dedicated on September 18, 1956. It brings to seven the number of major research centers operated by divisions of Union Carbide and Carbon Corporation, which in 1955 spent approximately $43 million on research.